INQUIRY

Information from the frontiers of knowledge

A magazine highlighting research at the University of Oregon

Spring 2000, Volume VI, Number 1

A Message About Research

Building a Better Mouse

Researcher works to help computer users get a better "feel" for their work

The Sky's No Limit

Researcher, astronomer, physicist -- he uses the Internet to help Oregon school children explore the stars

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Spring 2000

A Message About Research From

Tom Dyke
Vice Provost for Research

Our world is changing for the better through research and technology. Researchers at the University of Oregon are contributing to this advance by exploring important questions in many fields.

For example, a UO geologist is adding to our understanding of water and volcanic activity beneath the ground in Central Oregon.

Two UO professors are developing new approaches to training the next generation of chemists in a manner both rigorous and environmentally responsible.

One researcher is looking for ways for us to improve how we interact with computers, while another is investigating materials to help take computer chips to new levels of performance.

A physicist has invented a new device to study one of the oldest and most complex problems in nature.

An astronomer is combining the capabilities of the UO's Pine Mountain Observatory with the Internet to give Oregon school children first-hand experiences in conducting scientific research on the stars.

These researchers are truly working at the frontiers of knowledge, and each of us is benefiting from their trailblazing efforts.

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Spring 2000

Going Deep in Central Oregon

UO geologist finds link between spring water and underground volcanic activity -- with global "greenhouse" implications

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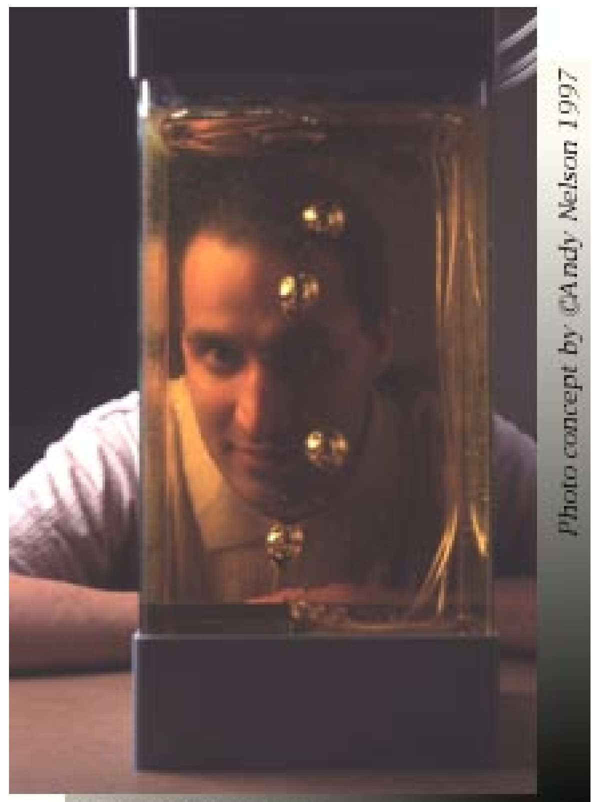
Observed from the surface, the rocky peaks of Oregon's central Cascade Range have appeared quiet since the violent eruption that formed Belknap Crater 1,300 years ago. Below ground, however, the central Cascades are anything but quiet.



Michael Manga

"We know there's a lot of water moving underground in Central Oregon, and we've thought there must be quite a bit of volcanic activity," says University of Oregon geologist Michael Manga, who is using advanced scientific techniques to understand what's going on underground. "Now, by analyzing spring water, we've learned in much greater detail just what's going on down there."

And this knowledge is vital. Why? Because much of Central Oregon is arid, almost a desert, with precious little water to spare. At the same time, the area's population-and need for water-is growing rapidly. The U.S. Geological Survey is interested in all aspects of the region's water supply and the UO researchers' work is adding to that understanding.

Manga and his team began their study by going to streams and rivers that originate from cold-water springs. For many Oregonians the most familiar example of a spring-fed river is the Metolius-not far from Sisters-which pours forth from the side of a hill as a fully flowing river.

"We took water samples then had them analyzed using the mass spectrometers at the Lawrence Livermore National Laboratory," Manga explains.

What humans see as simple spring water registers on the machine as a complex mix of compounds, molecules, and isotopes.

In studying the measurements, Manga read a telling tale of the unseen activity taking place beneath Central Oregon.

"We learned that when it surfaces water has usually been underground for a long time-a few years or even decades-and that it often travels quite a distance."

The water that comes out of Metolius, for example, originates not from nearby Black Butte but from the crest of the Cascades some thirty to forty kilometers (eighteen to twenty-four miles) away.

The researchers also discovered that the cold springs discharge large amounts of carbon dioxide that has as its source underground magma, or hot liquefied rock.

"We have long suspected underground volcanic activity in this region, but until now we didn't have any hard evidence for it," he says.

How can water tell the story of volcanic activity?

Under the great pressures within the Earth, liquid rock contains many dissolved gases, in much the same way that champagne holds gases that become bubbles once the cork is popped. The geological equivalent of a cork popping is a volcano erupting. For example, when Washington's Mount St. Helens erupted in 1980, huge volumes of gas escaped into the atmosphere.

"Our work has shown that in areas with lots of ground water and no erupting volcanoes-such as the central Cascades-the carbon dioxide from the volcanic source reacts with underground spring water and changes to bicarbonate, or common baking soda," Manga explains. "The bicarbonate is a form of carbon dioxide that dissolves in water and generally stays there. Our calculations show that thousands of tons of carbon dioxide from volcanic sources may be released annually from each of the spring-fed streams and rivers in Central Oregon."

In addition to telling Oregonians about their local landscape, the findings have more global implications.

Carbon dioxide is a "greenhouse gas," linked to global warming. In its fairly stable bicarbonate form, carbon dioxide does not directly contribute to the amount of the gas in the atmosphere. But it does clog up the so-called "carbon cycle" by which carbon dioxide is absorbed into water and thus scoured from the atmosphere.

The implications of these new findings could be significant, according to Manga, because they identify an additional source of naturally occurring carbon dioxide in the carbon cycle.

."This helps us understand in greater detail how the carbon cycle works and how it is changing climates today due to the huge volumes of carbon dioxide we've produced since the industrial revolution," Manga says. "Global warming is a pressing environmental concern that we need to understand. Our work in Central Oregon adds to what we know."

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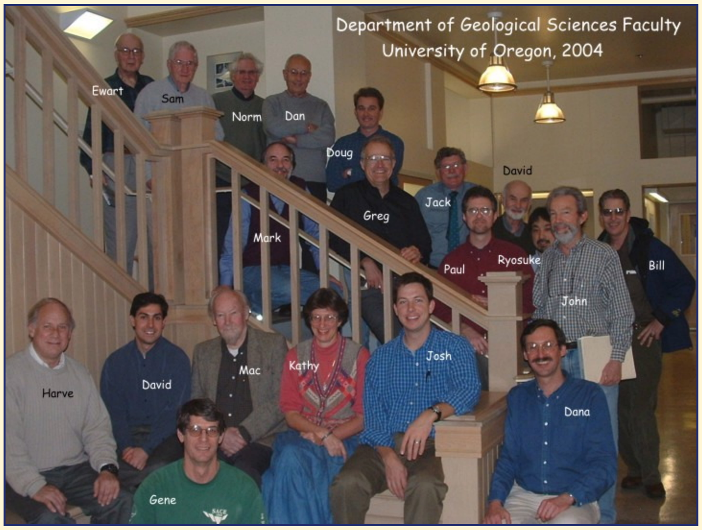

INQUIRY

Spring 2000

Scaling the Barrier to Smaller Microchips

Scientists investigate new materials to help industry shrink tomorrow's chips

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The ever-accelerating race to make microchips smaller and faster is heading for a brick wall. The tiny transistors that make up chips are quickly approaching physical barriers that will limit their continued miniaturization. Why? Because, simply put, beyond a certain amount of shrinkage, some of the materials used in traditional chip manufacturing just can't cut it.

Catherine Page holding a silicon wafer

The solution to this problem is of immense interest-and will mean billions and billions of dollars-to the fast-growing semiconductor industry.

"New materials with just the right combination of properties are needed to take the chip technology past this barrier," says Catherine Page, an associate professor of chemistry at the University of Oregon. "We're investigating a number of materials that are promising candidates to fill some of these needs."

Microchip manufacture takes place in a Lilliputian world, at a scale thousands of times smaller than what could be worked by even the most dexterous Gulliver wielding a soldering gun. For example, the "wires" down which the electrical current passes on a chip are infinitesimally small, a minute fraction of the width of a human hair.

"The electrical pathways and the buffering material that surrounds them are deposited onto the chip in extremely thin layers," says Page, who for more than a decade has conducted basic research on the properties of thin films and their deposition. "One of the goals we're working toward is finding materials that will give chipmakers the ability to lay down these pathways on a very small scale, very close together with very little electrical leakage."

.Page collaborates with David Cohen, a physics professor who measures the electrical properties of the films her group makes. Their work illustrates the process by which basic research drives technology that, in turn, is applied in useful and practical ways.

."Our research is an early but critical step in a long-term effort," she notes. "Many researchers are working on different aspects of the challenge of making smaller chips. Together, these efforts will help create the advanced chips that we'll all be relying on in ten or fifteen years."

.Page and Cohen are members of the UO Materials Science Institute (MSI), a group of scientists -- mostly chemists and physicists -- with research interests in the burgeoning field of materials. In the mid-1980s the Oregon Legislative Assembly gave the university funds to create the MSI as part of the Oregon Centers of Excellence program to promote the state's economic future. Since then, the institute has blossomed, growing to fourteen faculty members and between forty and fifty graduate students.

."In the past few years MSI has developed a synergistic relationship with some of Oregon's top high-tech industries," Page says. "MSI launched an applied master's degree program two years ago in collaboration with companies such as Hyundai, LSI Logic, and Planar Systems. The program gives students a great foundation in state-of-the-art semiconductor fabrication methods."

.The "microchip master's" program, as it is known informally, provides the student with classroom education, practical laboratory experience, and a six-to-nine-months industrial internship. The program has been an immediate success, both for the industrial partners and for the students, who often end up taking positions with participating companies.

."Our semiconductor program has been such a success that now we're expanding our focus to include the polymer industry, which manufactures a variety of useful products including glues, resins, and paints," Page says.

.Their close working relationship with the business sector has had an unexpected benefit for the MSI. Oregon high-tech businesses, including Intel and LSI Logic, have contributed a great deal of valuable "surplus equipment" to the program: microscopes fitted with digital cameras, sputter distribution equipment, and other useful hardware.

."Human ability to precisely manipulate materials for practical use has already come very far very fast," Page observes. "What is so exciting is that these abilities keep picking up speed."

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Photo of Mt. Hood by Bernd Mohr.
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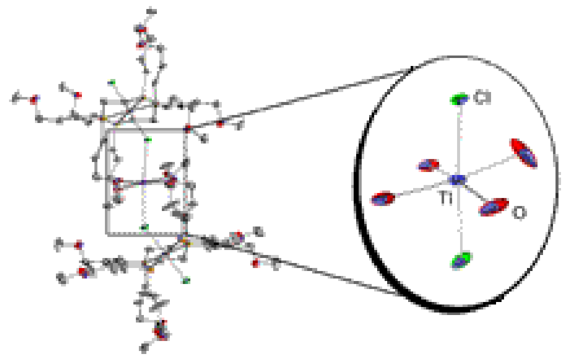
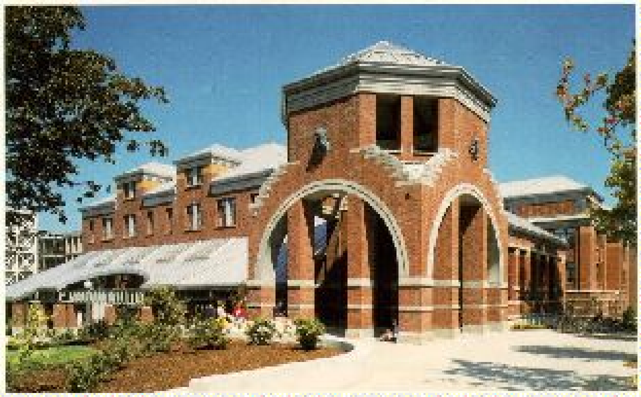


UO Lab Discovers Method to Assemble 1-D Coordination Polymers

Researchers in the Tyler lab recently demonstrated how "arrested" chloride abstraction reactions can be used to assemble 1-D coordination polymers.
PDF: Arrested chloride abstraction from trans-$RuCl_2(DMeOPrPE)_2$ with $TlPF_6$; formation of a 1-D coordination polymer having unusual octahedral coordination around Thallium(I). Nathaniel K. Szymczak, Fusen Han and David R. Tyler, Dalton Transactions, 2004, 3941 - 3942.
Learn More....



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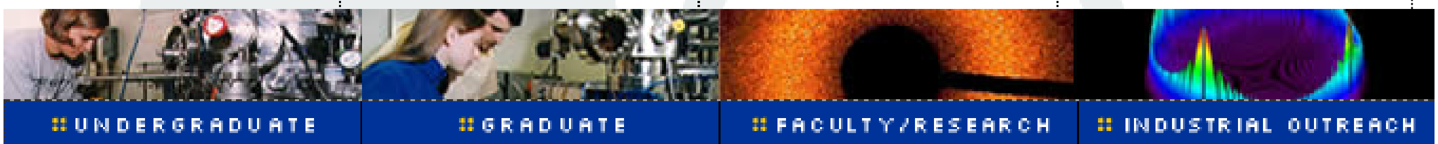
materials science institute
University of Oregon

The Materials Science Institute is an interdisciplinary institute of the University of Oregon. Founded in 1985 as a State Center of Excellence, the purpose of the Institute is to study the structure and properties of materials, to educate in the sciences of materials, and to serve Oregon as a resource in these sciences. Since 1985 the Institute has more than tripled the size of its research program, developed four new graduate programs in materials, and contributed to the State's prosperity through collaboration with more than 25 Oregon companies.



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INQUIRY

Spring 2000

"Green" Chemistry for a Better World

New methods prepare students to be tomorrow's environmentally responsible chemists

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Ken Doxsee and Jim Hutchison

.After several decades of tight environmental regulation, it now usually costs more to dispose of a hazardous chemical than to purchase it. Aware of this fact, industry is increasingly interested in low-waste, high-efficiency chemical processes-and in chemists trained to invent and carry out this environmentally benign, or "green," chemistry.

.Two faculty members of the University of Oregon chemistry department have developed a new approach to training chemists using practices that are environmentally sound, economically promising, and educationally innovative.

."Organic chemistry is used to develop and manufacture everything from plastics to life-saving drugs," says Ken Doxsee, one of the developers of the green chemistry course.

."Unfortunately, making these products often involves toxic chemicals that expose workers to hazards and require sophisticated disposal methods to avoid environmental contamination," adds Jim

Hutchison, who initiated the course project and developed it with Doxsee and a number of graduate students.

The key challenge they faced in devising the new course was developing green experiments. In some cases Doxsee and Hutchison substitute less hazardous chemicals for the corrosive or volatile chemicals used in more traditional "o-chem" laboratory courses. For other experiments, they took advantage of the latest green chemistry advances reported in scientific journals and modified them to address the time constraints of a laboratory class.

"It is only now that the practice of chemistry has advanced far enough that a green organic chemistry course could exist," Hutchison says.

To reduce hazards and waste, many chemistry departments across the nation over the last few decades have adopted "microscale" methods that reduce the quantities of all compounds used in an experiment. Smaller quantities result in proportionately less waste.

"But this approach really short-changes students," Hutchison says. "Microscale requires them to use minuscule amounts of chemicals with unusual specialized apparatus."

In other words, it has little to do with the kind of chemistry the students may eventually be asked to do when they take jobs in industry or academia.

"With green chemistry, we're able to teach students real chemistry techniques using real apparatus on a realistic scale," Doxsee notes.

By developing this new approach to chemical education, Hutchison and Doxsee aim to train chemists who are prepared to apply innovative and environmentally benign solutions to problems in industry.

"We see this as an important opportunity to transfer new technology from the university to the private sector," Hutchison observes.

The UO is building a new state-of-the-art green chemistry laboratory. Hutchison and Doxsee view this as the first step toward realizing their vision of making the UO a center for green chemistry education and research. They hope to work with foundations, the business community, government agencies, and other educators to make this center a reality.

"If we can teach students all the essential organic chemistry concepts and techniques that they need and at the same time prepare them to be the next generation of environmentally conscious chemists, then what's not to like?" Doxsee asks.

Their work is receiving praise from people in high places-such as Paul Anastas, the senior science analyst with the White House Office of Science and Technology Policy.

"There are few endeavors in science more important today than understanding how our skills and knowledge in manipulating molecules can be used to design products and processes which are more environmentally benign," Anastas says. "The work that Doxsee and Hutchison are doing . . . is going to be essential to the conduct of molecular science in the future. This is the heart of green chemistry."

Their work has also caught the attention of numerous publications, including Chemical & Engineering News and the Journal of Green Chemistry. For links to these publications as well as to other information about green chemistry at the UO, go here.

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Kenneth M. Doxsee

Professor
Organic, Organometallic, Solid-State,
& Analytical Chemistry

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Associate Member, Materials Science Institute

B.S., Stanford University, 1978. M.S., Stanford University, 1979 (James P. Collman). Ph.D., California Institute of Technology, 1983 (Robert Grubbs). Postdoctoral: University of California, Los Angeles, 1983-85 (Donald J. Cram). Honors and Awards: Fannie and John Hertz Foundation Fellow, 1979-83; American Cancer Society Scholar, 1984-85. At Oregon since 1989.

Research Interests:

The Doxsee research group carries out work in organic and organometallic synthesis, with special focus on the development of facile metal-mediated syntheses of complex organic molecules and on the synthesis of molecules with predesigned ability to complex selected substrates, and in solid-state organic and inorganic chemistry, focusing on "crystal engineering" issues.

Organotransition Metal Chemistry.

The unifying theme behind the group's work in this area is the examination of pericyclic reactions of organometallic complexes. As synthetic chemists, they are interested in the types of organic products that may be obtained; as organometallic chemists, they are interested in the structures and mechanisms of formation of the organometallic intermediates in these syntheses. Many of the group's reaction sequences involve cascades of pericyclic reactions, such as [2 + 2] and [4 +2] cycloadditions and electrocyclic ring-opening and closure, all of which are well precedented in organic chemistry but which were either rare or unprecedented in the arena of organotransition metal chemistry. These explorations, in addition to displaying a fascinating range of new reactivity patterns, also provide access to useful organic functionalities under conditions far milder than those used traditionally. Related chemistry leading to main group heterocycles is also under investigation, with focus on both mechanism and synthetic applications.

Complexation-Mediated Crystallization.

Simple organic and inorganic salts are often completely insoluble in nonpolar solvents. However, solutions of complexes of salts with crown ethers or other complexing agents in such solvents may be readily prepared. The group exploits this phenomenon in order both to recrystallize polar materials and to crystallize solid-state inorganic materials from nonaqueous solution. The unusual solvation conditions afforded by "complexation-mediated crystallization" play a dramatic role in the alteration of important crystal features including shape, size, and lattice. Given the critical importance of such properties to a remarkably diverse range of technologies ranging from photographic chemicals to "quantum dot" semiconductors, specific projects under investigation span a wide range of organic and inorganic materials.

Calcium Chelation.

The group is examining the interaction of the highly biologically significant calcium ion with various biologically relevant chelating agents including alpha-hydroxy ketones, such as the corticosteroids, and hydroxamic acids, which form the basis of a new generation of pharmaceuticals including anti-tumor agents. The group's work in this area ranges from synthetic organic, in the preparation of new chelating agents, to purely analytical, in the quantitative determination of formation constants and solution speciation profiles. It also includes a full range of solution and solid-state structural characterization techniques. As an outgrowth of the group's interests in both crystallization chemistry, as outlined above, and calcium chemistry, they recently began a concerted investigation of biomineralization, the process by which nature forms inorganic mineral phases such as the calcium carbonates (e.g., mollusk shells), and calcium phosphate (e.g., teeth and bones).

Selected Publications:

Doxsee, K. M. "Crystallization of solid-state materials via decomplexation of soluble complexes", Chemistry of Materials 1998, 10, 2610-2618.

Hanawalt, E. M.; Doxsee, K. M.; Weakley, T. J. R. "Reactions of tungsten pentacarbonyl and mercuric chloride complexes of 1,3,4-triphenyl-1,2-dihydrophosphete"; Heteroatom Chemistry 1998, 9, 21-28.

Doxsee, K. M.; Chang, R. C.; Chen, E.; Myerson, A. S.; Huang, D. "Crystallization of solid-state materials in nonaqueous gels. I. Silver bromide"; J. Am. Chem. Soc. 1998, 120, 585-586.

Doxsee, K. M.; Wierman, H. R. "Crystallization of salts of organic acids from non-conventional solvents"; Molecular Crystals and Liquid Crystals 1998, 313, 285-292.

Doxsee, K. M.; Juliette, J. J. J.; Nieckarz, G.; Zientara, K.; "Methane elimination and the formation of titanacycles: High regioselectivity in intramolecular C-H activation reactions of titanocene complexes", J. Am. Chem. Soc. 1994, 116, 2147-2148.

Additional Publications

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James E. Hutchison

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Director, Materials Science Institute
Hutchison Lab

B.S., University of Oregon, 1986. Ph.D., Stanford University, 1991 (James P. Collman). Postdoctoral: University of North Carolina at Chapel Hill, 1992-94 (Royce W. Murray). Honors and Awards: Phi Beta Kappa; Franklin Veatch Fellowship, Stanford 1987-89; Centennial Teaching Assistant Award, Stanford, 1990; NSF Postdoctoral Fellow, 1992-94; Camille and Henry Dreyfus New Faculty Award, 1994; NSF CAREER Award, 1997; Alfred P. Sloan Research Fellow, 1999; Camille Dreyfus Teacher-Scholar, 1999. At Oregon since 1994.

Principal Research Interests

Research in the Hutchison lab focuses on molecular-level design and synthesis of functional materials, including ligands, surfaces and low-dimensional nanostructures. In each area we design structures to exhibit a desired function and test the efficacy of the new materials for specific applications. To prepare functional nanostructures and extended materials we prepare functionalized organic and inorganic chemical building blocks that are designed to assemble into organized structures such as two-dimensional films (monolayers) or one-dimensional arrays (lines). We test ideas about the preparation of complex molecular assemblies in solution and on surfaces and try to understand how the structure of the building blocks influences the assembly's structure, reactivity, stability, and electronic properties. Whenever it is feasible our designs for new processes and materials are based upon the principles of green (environmentally-friendly) chemistry. Our synthetic efforts are directed toward the preparation of well-defined materials for elucidating structure/property relationships. Physical characterization of these samples presents a challenge that is met through application of a wide range of instrumental methods.

Functionalized Gold Nanoparticles and Nanoparticle Arrays

Nanoscale electronic devices based upon single-electron charging are promising candidates for smaller and faster electronic circuits. New methods of nanofabrication are needed to attain these small dimensions. One method, that we have termed ³biomolecular nanolithography,² involves assembly of metal nanoparticles onto biopolymeric (polypeptide and DNA) scaffolds to form lines and more complex patterns.. We arrange specifically-functionalized gold nanoparticles into nanoassemblies that exhibit single-electron charging effects at room temperature. We continue to explore the potential of biomolecular nanolithography as an approach to generating molecularly-integrated nanocircuits and as a greener approach for the future of the microelectronics industry. We are also exploring the reaction chemistry of the gold particles so that we can tune the particle's solubility, reactivity, and interparticle spacing utilizing unique mixtures of inert capping and reactive bridging ligands. The electrical properties of the functionalized nanoparticles and their nanoscale arrays are being investigated to obtain a fundamental understanding of electron transport in these nanoscale systems.

Conformationally-Preorganized Malonamides as Ligands and Materials for F-Block Ion Chemistry

Designing effective metal ion receptors is an important challenge in inorganic and supramolecular chemistry. In addition to improving our understanding of ion-receptor interactions, such studies lead to new receptors that are useful in applications that involve sensing, separating, sequestering, and delivering metal ions. We recently discovered that by ³preorganizing² a malonamide ligand so that the donor groups are ideally positioned for binding, a dramatic (10 million-fold) enhancement in binding for f-block ions is achieved. This discovery provides an opportunity to explore the coordination chemistry of this new ligand class and to use the members of this class as building blocks for the preparation of functional materials. On-going efforts involve development of methods for preparing new ligands and materials; characterization of the ion affinity and selectivity of new ligands; and discovery of materials for applications, including membrane-based separations, ion-sensitive surfaces, polymeric ion sequestering agents, etc.

Interchain Hydrogen Bonding in Organic Monolayers on Metal and Oxide Surfaces

Organic thin films on surfaces are important model systems for studying interfacial phenomena and have a number of important applications in fields ranging from materials science to biomedicine. Self-assembled monolayers (SAMs) are formed by adsorption of molecules onto surfaces to yield a single molecular layer. We pioneered the study of amide-containing monolayers wherein lateral hydrogen bonding between the molecules occurs in the plane of the SAM. By designing molecules with specific hydrogen bonding sequences, we can control the structure, stability and electronic properties of the SAM. In the case of mixed monolayers, we have used hydrogen bonding to drive nanoscale patterning of the surface through phase separation. Currently we are designing new adsorbate molecules through which we can systematically control nanoscale patterning and monolayer stability on metal and oxide surfaces.

Selected Publications:

35. Reed, S. M.; Hutchison, J. E. ³Green Chemistry in the Organic Teaching Laboratory: An Environmentally Benign Synthesis of Adipic Acid,² J. Chem. Educ. 1999, 77, 1627-1629.

45. Weare, W. W.; Reed, S. M.; Warner, M. G.; Hutchison, J. E. ³Improved Synthesis of Small (dCORE =1.5 nm) Phosphine-stabilized Nanoparticles² J. Am. Chem. Soc., 2000, 122, 12890-12891.

46. Smith, R. K.; Reed, S. M.; Lewis, P. A.; Monnell, J. D.; Clegg, R. S.; Kelly, K. F.; Bumm, L. A.; Hutchison, J. E.; and Weiss, P. S. ³Phase Separation within a Binary Self-Assembled Monolayer on Au {111} Driven by an Amide-Containing Alkanethiol,² J. Phys. Chem. B., 2001, 105, 1119-1122. Cover.

49. Brown, L. O.; Hutchison, J. E. ³Formation and Electron Diffraction Studies of Ordered 2-D and 3-D Superlattices of Amine-stabilized Gold Nanoparticles,² J. Phys. Chem. B 2001, 105, 8911-8916.

53. Lumetta, G.J.; Rapko, B.M.; Garza, P.A.; Hay, B.P.; Gilbertson, R.D.; Hutchison, J.E. ³Deliberate Design of Ligand Architecture Yields Dramatic Enhancement of Metal Ion Affinity,² J. Am. Chem. Soc. 2002, 124, 5644-5645. Highlighted in Science Magazine as an Editors' Choice article "Designer Bindings" (2002, 296, 985) and in Chemical and Engineering News as a Science Concentrate "Designed Ligands Boost Metal Binding" (2002, 80(20), 37). Also highlighted on the Department of Energy Office of Science homepage.

59. Warner, M. G.; Hutchison, J. E. "Formation of linear and branched nanoassemblies of gold nanoparticles by electrostatic assembly in solution on DNA scaffolds," Nat. Mater. 2003, 2, 272-276. Highlighted in News and Views in Nature Materials 2003, 2, 214-215.

Additional Publications

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green Organic Lab

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The story behind our Green Organic Lab

(For a graphic outline of our green organic lab curriculum, check out our slide show.)

In 1998-99 a green lab was offered as an alternative to the normal organic lab sequence at the University of Oregon. This two-term sequence, taught by Jim Hutchison and Ken Doxsee consisted of two sections with twelve students each. Additionally, three teaching assistants, Marvin Warner, Scott Reed, and Brad Wan worked with the students in the lab and continue to optimize and test new green laboratory experiments. For the 1999-00 year, the green lab was expanded to a class of 30 students, to further test the experiments, conduct monitoring of waste production and air monitoring. Today, all organic labs are taught in the green format in our new green organic lab.

The goal in designing this course was two-fold. We sought to teach students the core organic synthesis laboratory skills while demonstrating, first hand, the benefits of an approach that uses greener reagents, reaction conditions and products. Our belief is that the introduction of greener experiments will improve safety, allow for the routine use of macroscale techniques, and provide an ideal context for the discussion of chemical safety.

One of the challenges in developing this course was developing new laboratory experiments, as there are very few examples in current lab manuals. Our criteria for identifying green experiments for this new curriculum were that each experiment:

- Illustrate green chemical concepts (e.g. recycling, hazard reduction, solvent reduction)
- Teach modern reaction chemistry and techniques
- Complement the lecture course and provide a platform for discussion of environmental issues in the classroom
- Be accomplished by students given the time (3 hours) and material constraints of a typical student organic laboratory
- Is adaptable to either macroscale or microscale methods

- Uses inexpensive, greener solvents and reagents
- Reduces laboratory waste and hazards
- Each term of the lab course consists of 7 labs that were either designed from scratch or modified from existing labs to meet the above criteria.

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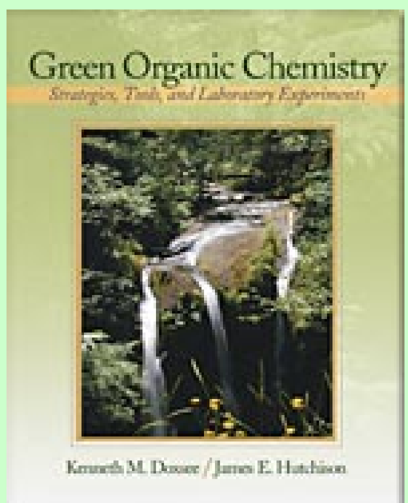
UO Chemistry Department

green Chemistry
At the University of Oregon

We are currently accepting applications for our Green Chemistry in Education Workshop 2005 - see *the NSF Center for Workshops in the Chemical Sciences website:* *click here for application*



To find out more about our textbook, "*Green Organic Chemistry - Strategies, Tools and Laboratory Experiments"* published by Brooks-Cole Publishing, 2004; *click here*

The Green Chemistry Program at
the University of Oregon has enjoyed financial support from the Environmental Protection Agency and the American Chemical Society.

Green Chemistry News at Oregon

Newsbriefs on the Greening of our department.

- Graduate Student wins Green Chemistry Award
- New Green Organic Lab finds Success
- Media Coverage
- WHY Green Chemistry?
- Slide Show detailing our green organic curriculum

What is Green Chemistry?

The principles of green chemistry focus on reducing, recycling, or eliminating the use of toxic chemicals in chemistry by finding creative ways to minimize the human and environmental impact without stifling scientific progress.

Chemical synthesis which takes into account environmental considerations in the selection of reactants and reaction conditions is growing in importance as both industrial and academic researchers become aware of the environmental and economic advantages of an environmentally benign or "green" approach. The principles of a green approach are not covered in traditional chemistry courses, perhaps contributing to its slow growth as an area of academic research.

Finding creative ways to reduce hazard and waste has been the goal of many academic labs across the country. In recent history, the trend has been toward "microscale" methods; using smaller quantities of reactants to minimize the impact.

In contrast, green chemistry focuses on using less toxic reactants in the first place, thus reducing the need to use microscale methods. Students in a green chemistry lab can use quantities more typical of an industrial setting than their counterparts in a microscale lab. Finding realistic solutions to environmental concerns in academic labs should prove to be a boon to industry as they look for employees ready to meet the demands of the future of science.

At Oregon, we are setting the stage for becoming a national center devoted to green chemistry education and research by developing innovative educational materials and research programs based on green chemistry principles.

Green Chemistry at Oregon • Green Organic Lab • Green Chemistry Resources • Media Coverage

UO Chemistry Department

Webmaster: lynde@oregon.uoregon.edu

INQUIRY

Spring 2000

All Shook Up

UO physics team produces 1,000-fold increase in measurement of turbulence

---

.From the time of Leonardo da Vinci's famous sketches of the churning forces at work in roiling water, scientists have been trying to understand one of the universe's most elusive mysteries-turbulence. Now a research team headed by University of Oregon physicist Russell Donnelly has pushed forward science's ability to produce and measure turbulent flows in the laboratory a thousand fold.

RUSSELL DONNELLY

."We've attained levels of thermal turbulence three orders of magnitude beyond what has been reached before," says Donnelly. "This is by far the most intense thermal turbulence ever achieved on earth in a controlled experiment."

.Donnelly sees his work as an important step forward for science.

."Fluid turbulence is undoubtedly the most outstanding problem of classical physics that has remained unsolved to this day," he says. "Despite over 200 years of focused research, there is no comprehensive theory of turbulence. This is quite remarkable."

.While the new findings do not provide the elusive comprehensive theory, they are expected to shed light on some important and practical questions.

.For example, scientists have previously been unable to model accurately the intense levels of turbulence that develop around moving bodies-from the wind roaring over the wing of a 777 jet aircraft in flight to the water swirling around the hull of a ship plowing through the sea. Advanced understanding of turbulence will assist environmental scientists in modeling the gargantuan churning motion of oceanic and atmospheric currents. Donnelly's work even puts scientists within reach of modeling one of the most turbulent places in the solar system-the surface of the sun.

.The findings, recently published in the prestigious scientific journal Nature, are the result of work begun in the fall of 1996, when the National Science Foundation (NSF) awarded Donnelly and his coresearchers five million dollars to develop technology to produce and study high intensity turbulence.

.The research group formed the Cryogenic Helium Turbulence Laboratory (CHTL), housed on the University of Oregon campus, and developed an advanced low-temperature testing device. Known generically as a cryostat, the device looks something like a thermos bottle for Paul Bunyan-one meter tall and filled with extremely cold helium gas. At such low temperatures (about 450 degrees Fahrenheit below zero or just a few degrees above absolute zero), helium gas is the slipperiest fluid known to science.

."I believed this slipperiness would make low-temperature helium the perfect substance for studying turbulence," Donnelly says. He was right.

."The cryostat worked like gangbusters, right out of the chute," he reports. "Nothing I know of in physics covers such a wide range of observations in one apparatus."

.The research team already is at work on a number of new experiments and techniques.

.But the CHTL group's vision for pushing the limits of what is known about turbulence goes far beyond what is already in the works. The NSF originally funded the cryostat as a pilot project. Now, having demonstrated its success in the pilot program, the CHTL research group hopes to build a ten-meter-high, five-meter-diameter cryostat that will hold 60,000 liters (about 15,000 gallons) of helium.

."Such a cryostat could push up our abilities to produce and measure turbulence by another factor of a thousand," Donnelly says.

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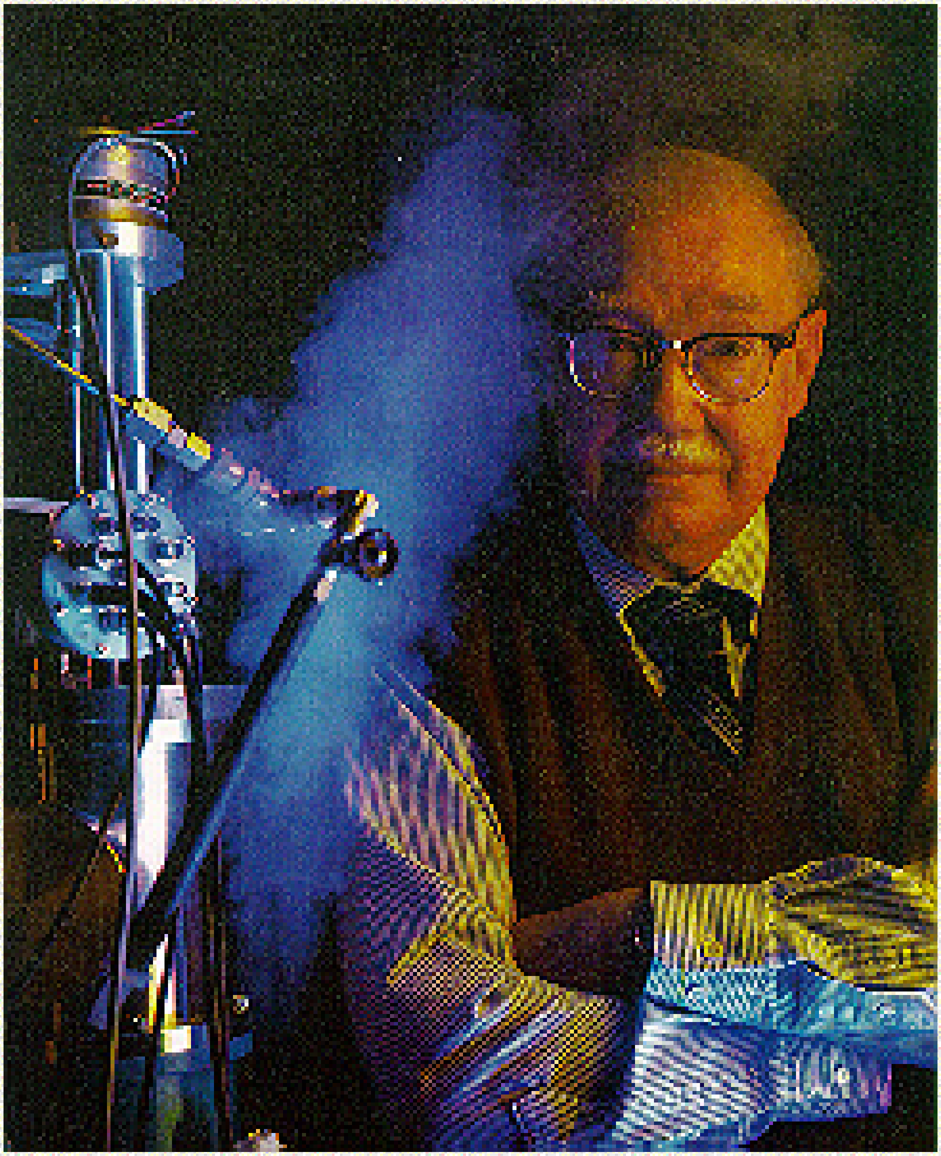

Russell Donnelly; Professor; Ph. D. 1956, Yale

- *At UO since:* 1966
- Director, Cryogenic Helium Turbulence Lab
- *Field of Specialization:* Fluid Dynamics
- *Research Interests:* Low temperature physics; turbulence in liquid helium
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fax: 541-346-4708
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office: 161 Willamette or 40 Willamette

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INQUIRY

Spring 2000

Building a Better Mouse

Researcher works to help computer users get a better "feel" for their work

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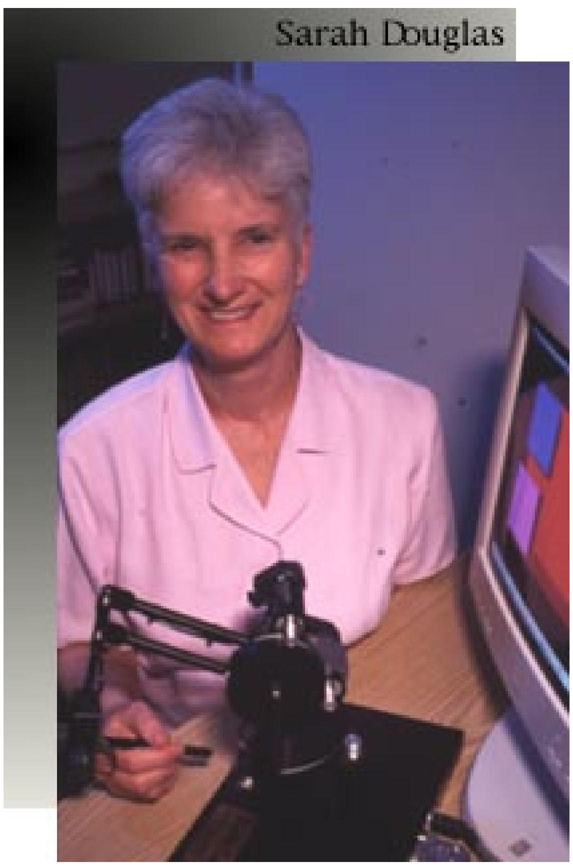

.The way most of us communicate with our desktop PCs, via keyboard and mouse, has remained virtually unchanged over the years even as the PCs themselves have grown vastly more powerful.

.Sarah Douglas, who heads the University of Oregon's Department of Computer and Information Science (CIS), is looking beyond the mouse in search of innovative ways to interact with computers.

."How can we make pointing devices faster and better for people?" she asks. "How can we make them easy to learn and use, and how do we integrate them with software?"

.Douglas notes that many people assume that the next major advance in computer interaction will be to the kind of voice interactions long prophesied in science fiction, from 2001: A Space Odyssey to Star Trek. But she has her doubts.

."Hearing and understanding spoken language is an incredibly difficult problem that the human brain is especially well suited for," she says. "Adapting computers to this task is monumentally challenging."

.A number of other technologies may hold more immediate promise. Douglas is exploring one approach that uses the sense of touch. Engineers have developed an instrument [see photo] that allows a user to "feel" objects in three dimensions. As the user grasps a penlike stylus to move objects that appear on the monitor screen, the stylus simulates texture, weight, and hardness.

Understanding the nature of that interaction-its limitations as well as its possibilities-should help researchers continue to refine this and other devices, says Douglas, author of the recent book, Ergonomics of Computer Pointing Devices.

"This work gets to some very basic and important questions," Douglas says. "What is touch, how do we perceive it, and to what extent can it be used as a way to interact with a computer? Answers to these questions are coming, in part, through the application of theories and experimental methods from the field of psychophysics. This field also is helping us come to a deeper understanding of computer operating systems."

Applications of 3-D computer interactions are practical and broad-ranging. Architects are already using virtual representations of the buildings they design in order to adjust the designs in accord with the virtual experience of being in the structure.

Another promising application is for individuals without the visual capacity to interact fully with today's graphic interfaces, which rely heavily on the user's sight.

Douglas recently guided the CIS department past a milestone when it celebrated three decades of operation.

"Like most of the early CS departments, we have our roots in the mathematics department, where the computational value of computers was clear early on," she says.

Computing has changed significantly from the early 1960s, when the university's IBM 360 mainframe computer was the only system available. Operators used punch cards to communicate with it. Those early machines have now been replaced by computers that interact personally with each user through a graphical user interface-something that has become possible only through immense innovations in computer speed, storage, and programming.

The burgeoning CIS department got a substantial upgrade with the completion of its own 30,000-square-foot building, Deschutes Hall, a little more than a decade ago.

Initially, the computer and information science major led to B.A or M.S. degrees; the Ph.D. was added in 1982. One of the larger departments on campus, CIS had 546 students enrolled at all levels in the fall of 1999. Over the course of three decades, CIS has awarded more than 1,800 degrees.

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University of Oregon
Computer & Information Science

Sarah A. Douglas, Professor

Education

AB, 1966, University of California at Berkeley
MS, 1979, PhD, 1983, Stanford University

Research Areas

- **Human-Computer Interaction**
  Experimental Studies of Human Behavior with User Interfaces
  Input Devices, Visual Feedback, Visualization
  Tools and Methods for User-Centered Design and Usability Evaluation
  Learner-Centered Software
- **Bioinformatics and Computational Biology**
  Cardio-Vascular Construction Kit
  Zebrafish WWW Database Resource (ZFIN)

Curriculum Vitae

Research: Human Computer Interaction Group

Fall 2004 Honors College course "Democracy & Technology HC 441H University of Oregon Blackboard website

Fall 2004 CAS College Scholars: Sciences seminar CAS 220

Winter 2005 Intro to User Interfaces CIS 443/543 (syllabus)

Spring 2005 Modelling & Simulation CIS 445/545 (last year's syllabus)

Spring 2005 HCI graduate seminar CIS 607 (last year's syllabus)

OFFICE HOURS Winter 2005: MWF 1-2pm

(541) 346-3974
email: douglas AT cs.uoregon.edu

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send feedback to: webmaster@cs.uoregon.edu

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Computer and Information Science
at the University of Oregon

- Research
- Education
- People
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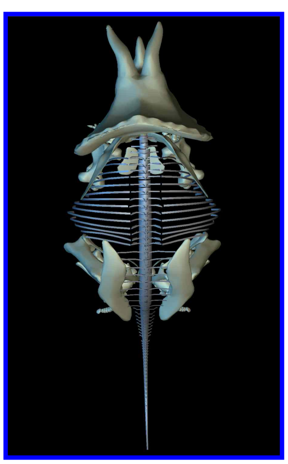

Bioinformatics Research Published in *Nature*

 CIS graduate student, Bryan Kolaczkowski, and UO assistant professor of biology, Joe Thornton, used a small supercomputer to simulate the evolution of thousands of gene sequences on a hypothetical evolutionary tree. (cont.)

Colloquium Honors Work of Prof. Andrzej Proskurowski

 The Department recently hosted a special Colloquium honoring CIS theory faculty Dr. Andrzej Proskurowski on the occasion of his birthday. (cont.)

Welcome to New AI Faculty Dejing Dou

 The CIS department welcomes our newest faculty member, Assistant Professor Dejing Dou, whose research focuses on practical as well as theoretical aspects of Artificial Intelligence, Databases, Biomedical Informatics and the Semantic Web. (cont.)

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INQUIRY

Summer 2000

The Sky's No Limit

Researcher, astronomer, physicist -- he uses the Internet to help Oregon school children explore the stars

Physicists have a big problem -- they can't account for about 95 percent of the universe. No kidding, the vast majority of the matter that Newton and Einstein say ought to be there has for decades eluded discovery by space scientists.

To explain the missing matter, the researchers have developed the idea of Dark Matter -- vast amounts of stuff that is floating unseen somewhere in the universe. The only problem is that no one has found any Dark Matter.

"After a lot of looking, we are quite sure there isn't any Dark Matter within 100 light years of earth," says Gregory Bothun, a University of Oregon physicist and astronomer.

That's 500 trillion miles.

Bothun is now conducting an experiment that could help solve the riddle of Dark Matter. He's testing out an explanation for the missing matter which, in simple terms, suggests that across the vast distances of space the laws of Newton and Einstein operate a little differently than they do between, say, the earth and the moon. If so, then the calculations from which scientists conclude that much of the universe is missing would themselves be based on false assumptions. Fix the assumptions and-poof-away goes the need for Dark Matter.

"We are really faced with two untenable possibilities," Bothun says. "Either we must believe in Dark Matter without really understanding anything about it or we must believe that Newtonian gravity doesn't work the way we thought it did."

To get to the bottom of this perplexing question, Bothun is using the world's most powerful instrument for viewing the stars-the Hubble Space Telescope (HST). He aimed HST at a test-case galaxy and over a period of two months precisely measured its gravitational action. He is now analyzing these measurements to determine if they support or are in conflict with accepted notions of physics.

If he discovers a conflict, the problem of Dark Matter would change dramatically. But others would arise.

"Einstein's theory would suddenly be grossly incomplete," he says. "And we'd need to ask what in nature allows for this strange violation of what we've believed to be true."

The data analysis should be completed in the fall.

Bothun also uses telescopes a little closer to home. He serves as director of the UO's Pine Mountain Observatory (PMO).

Not far from Bend, on a perch 6,400 feet above sea level, PMO's telescopes peer up into one of the darkest skies on earth.

"A dark sky is important because the darker the sky, the better for observing faint and distant objects with a telescope," he says.

Oregon's only professional astronomical observatory, Pine Mountain has been in operation since 1967. Its three large telescopes whose mirrors are 15, 24 and 32 inches in diameters, are used for both research and education. PMO is one of the few professional observatories open to the public at night.

Public viewing (for age ten and up) takes place on Friday and Saturday nights from Memorial Day through September. Following an introductory lecture, visitors can observe a variety of celestial objects such as the moon, planets, nebulas, and galaxies. Experienced amateur astronomers from the Friends of Pine Mountain Observatory group (FOPMO) are on hand to answer questions and operate the telescopes.

Observatory staff members provide demonstrations of one of the latest techniques available to astronomers: gathering images with a supersensitive electronic "CCD camera" and enhancing those images with the aid of computers.

"We get 2,000 to 3,000 visitors a year," Bothun says. "And many people are surprised to learn how professional astronomy is done these days-not by looking through a telescope with the human eye but with modern detectors and digital imaging."

.The observatory hosts amateur "star parties" at which local astronomers bring their own telescopes and set them up them around the observatory site.

."We're happy to host these parties," Bothun says. "It gets more people directly involved in astronomy."

Photo by Fred Domineack

.For those not able to make the trip to the observatory, FOPMO maintains an active outreach to Oregon schoolchildren through 200 to 250 classrooms visits a year. These sessions, available in Spanish or English, teach students about modern astronomy, digital images, and digital processing with the help of small digital cameras and computers provided by FOPMO volunteers.

.The advent of "digital astronomy" and the rapid expansion of the Internet are opening another door for delivering the resources of PMO to Oregon school children. For several years Bothun has been working to make PMO a remote-access observatory.

."In essence, this means that the telescope can be used over the Internet," he says.

.A teacher at an Internet-connected classroom can send aiming coordinates to a PMO technician who then manually positions the telescope. The telescope acquires the target images, which are then sent in digital form back to the classroom for the teacher and students to analyze.

."It allows students to do real astronomy, to make their own measurements and to learn principles from their own observations and calculations -- not from reading them in a book," Bothun says. "That's real science and a real opportunity for school kids in Oregon."

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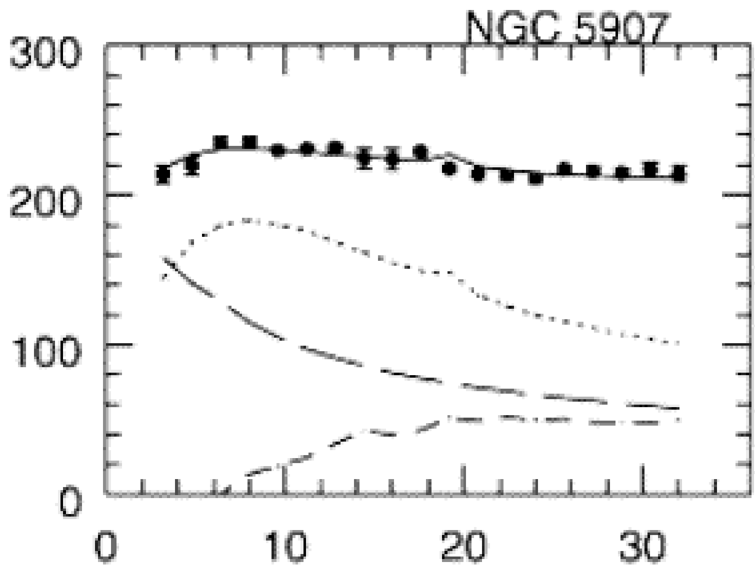


Dark Matter or Different Gravity?

Greg Bothun, Department of Physics, University of Oregon

Ground Rules:

Two choices that result from studying the kinematic properties of objects outside our solar system.

1. **Unseen matter is required to account for the mass inferred from the kinematics**
2. **Our choice for the acceleration on that matter needs to be modified**

Both of these are empirical statements

This leads to two possibilities:

***When you have eliminated the impossible, whatever remains, however improbable, must be the truth* (Sherlock Holmes)**

***What gets us into trouble is not what we don't know. It's what we know for sure that just ain't so* (Yogi Berra)**

So we are really left with two untenable positions. Either we must believe in Dark Matter without really understanding anything about its possible form or we must believe that Newtonian Gravity is modified on large scales.

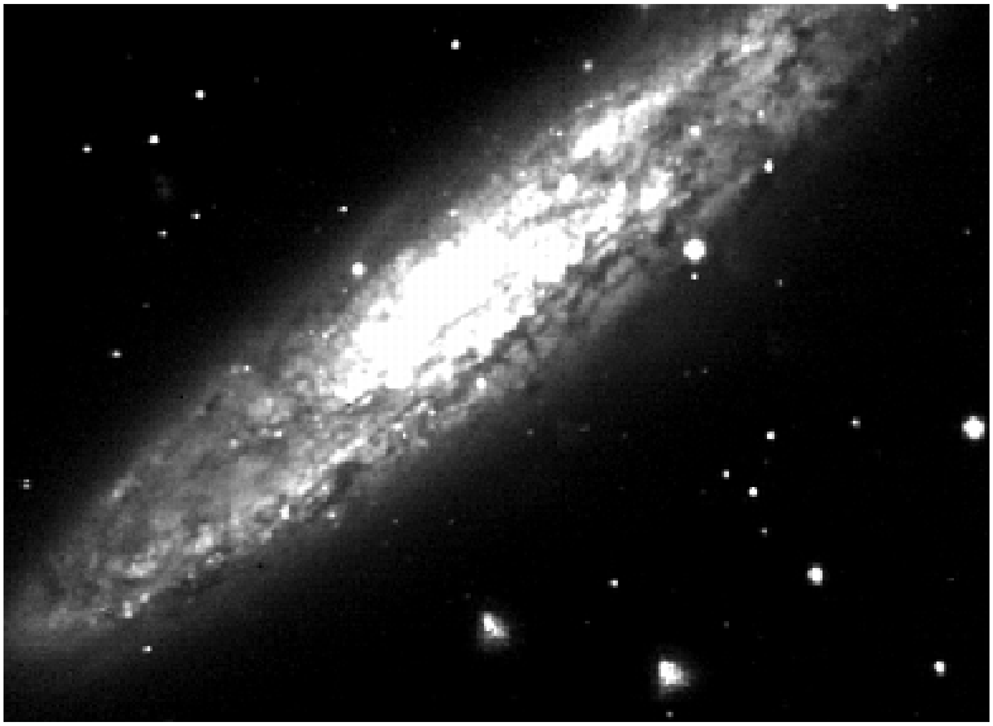
We are driven to these positions by observation and hence the GROUND RULES are that none of this is reproducible via first principles so DON'T ASK.

Thus Endeth the Ground Rules

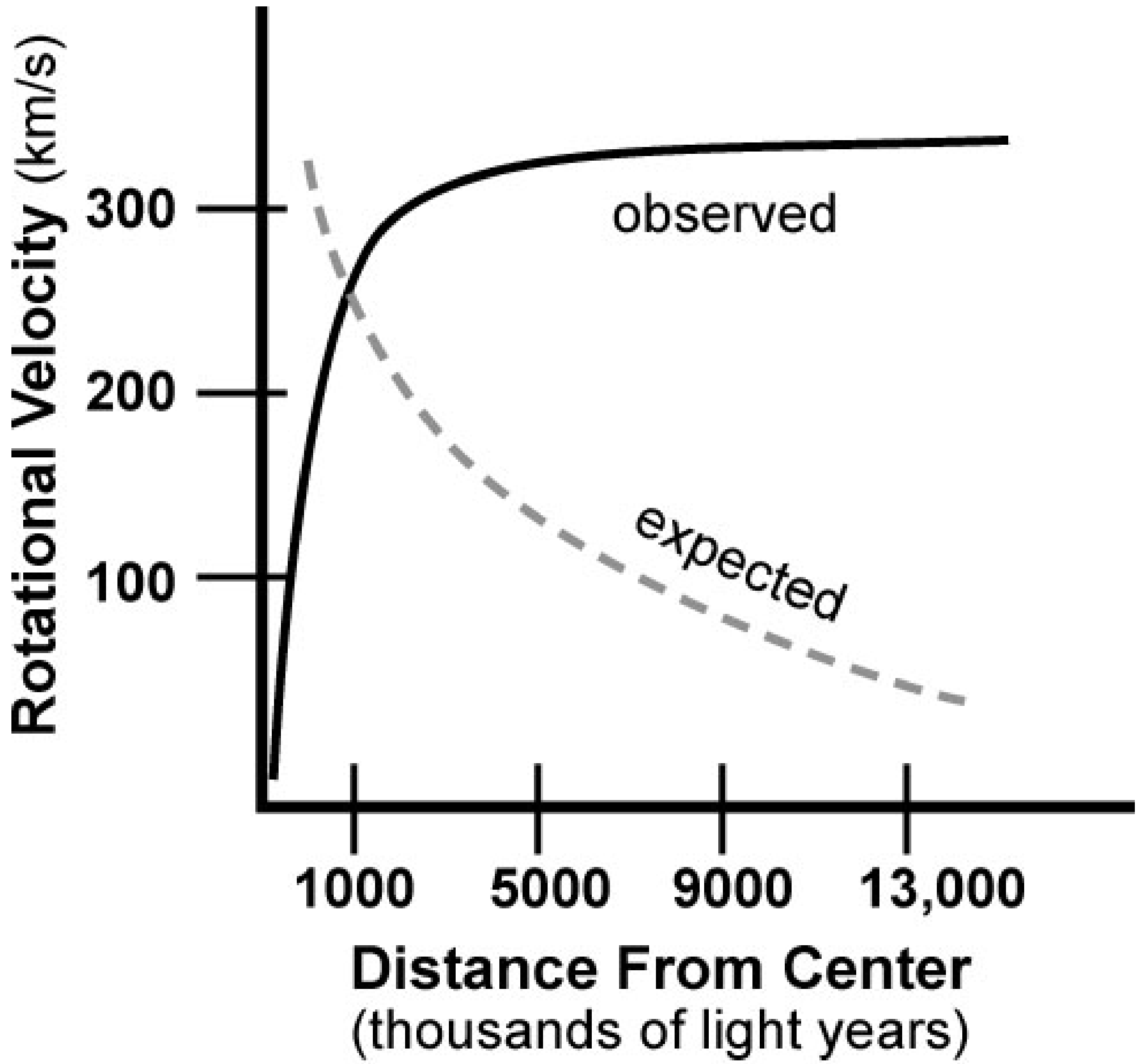
Page 2

Overview of the Evidence for Dark Matter on Different Scales:

- ## Galactic Scales:

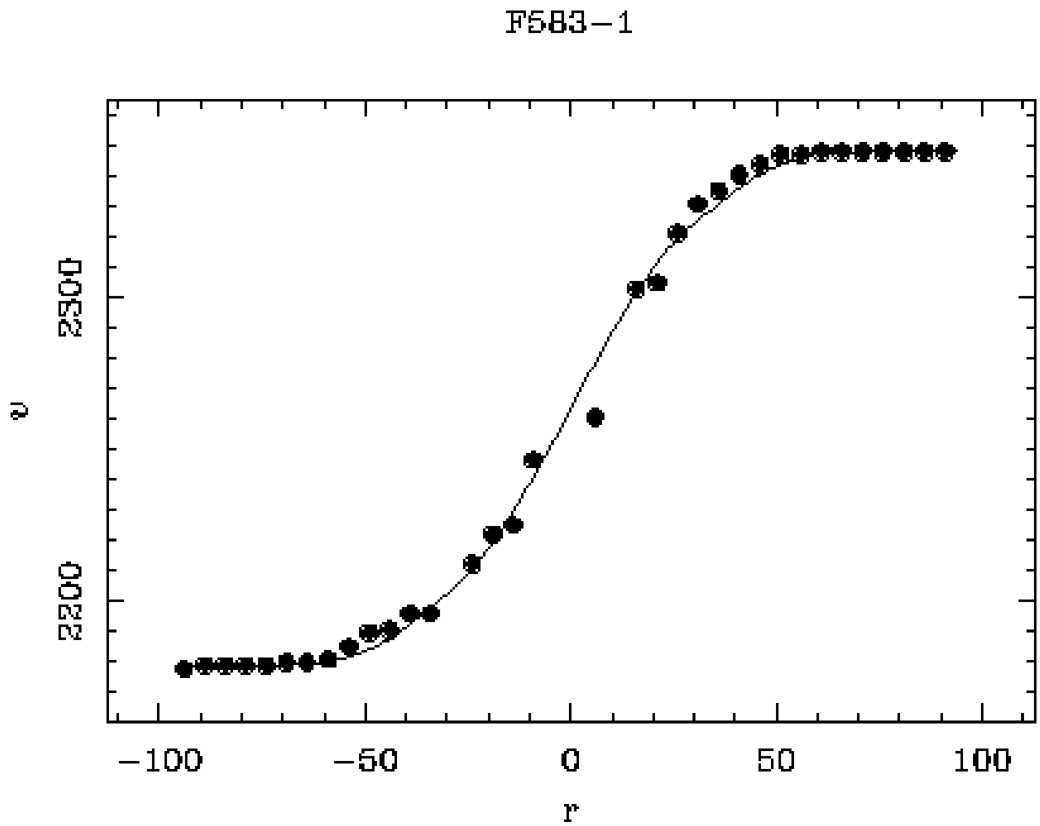


If light traces mass in a galaxy then we expect a Keplerian fall off in rotational velocity as a function of radial distance.



This is never observed in any galaxy:

Some sample rotation curves:

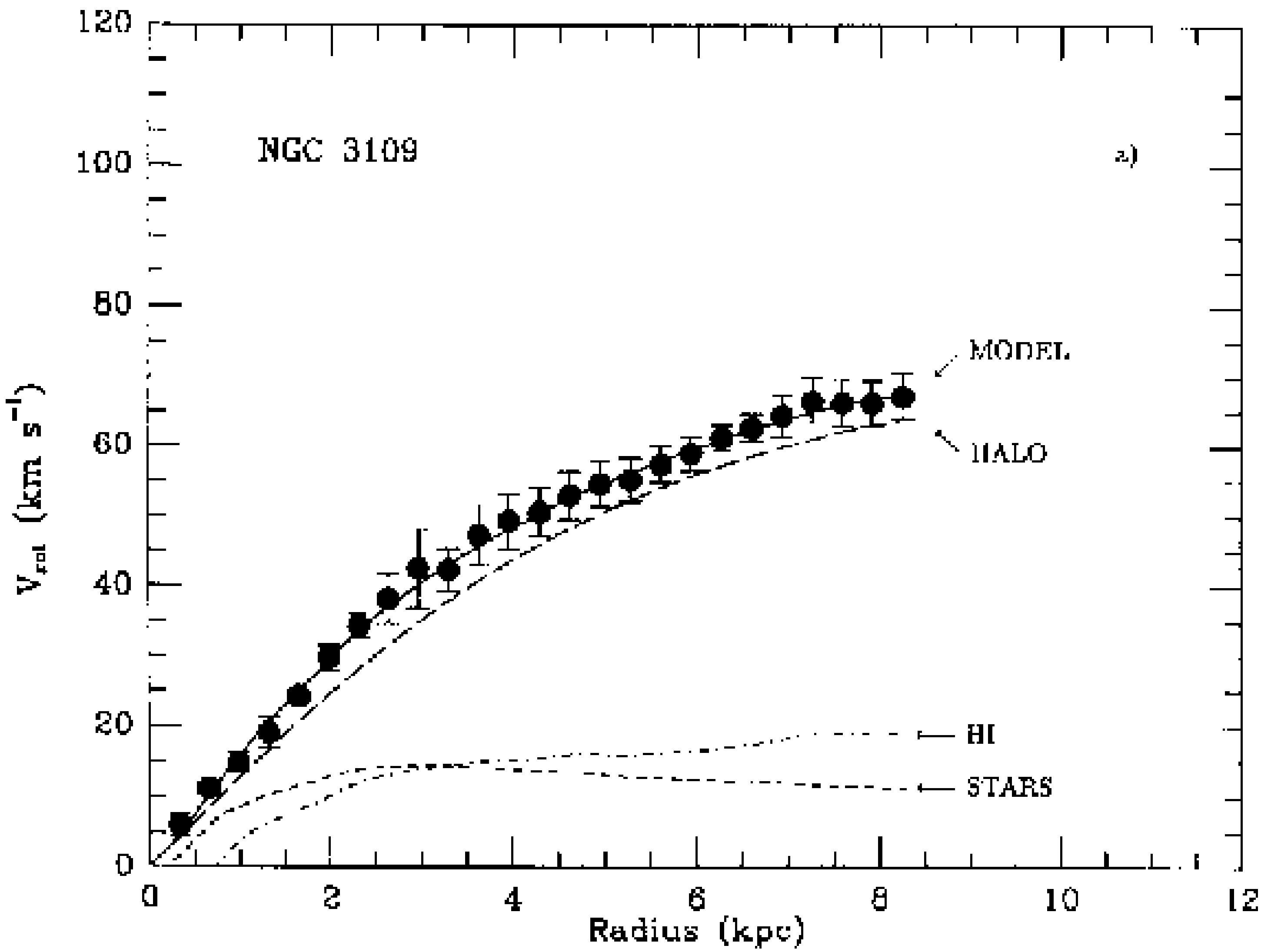


In most all observed cases, the rotation curve is either flat or rising within the optically observed part of the galaxy. Note that, in general, spirals have an exponential light distribution:

$$I(r) = I_o e^{-(a/r)}$$

The optical portion of a galaxy usually encompasses about 3 scale lengths (*a*) of light. If the mass distribution is also exponential and remembering that the circular velocity goes as $(M/R)^{(1/2)}$, then one can show numerically that for an exponential mass distribution the quantity *M(r)/R* reaches a maximum at 2.17 scale lengths which is about the optical extent of a galaxy. Thus, optical rotation curves could be somewhat flat, they are not unambiguous probes of the Halo.

However, there do exist some galaxies which have large gaseous extents relative to their optical extent. In some cases, this gas has a radial extent of 10 scale lengths and hence the circular velocity is dominated by an extended halo. If not, the circular velocity would fall off rapidly once the optical edge of the galaxy is reached. An excellent example of this is shown below for NGC 3109.



In the above example, the data is fitted against mass contributions from the gas, stars and dark matter in the halo. For this case its obvious that the halo dominates but is this Universal?

Caveats: Perhaps only galaxies with extended dark matter halos

are capable of retaining large gaseous extents?

In any event, the rotation curve data, in general, suggests that 90% of the mass of a galaxy is distributed in some spherical halo which contains very little light.

The observation that the circular velocity is independent of radius implies that M(r) grows with R. This in turn requires a density distribution of the form:

$$\rho(r) = \frac{1}{4\pi r^2}\frac{dM(r)}{dr}$$

This density profile can be recovered by using an isothermal sphere in hydrostatic equilibrium. That derivation is given here

☞ **Page 4**

Gregory Bothun: Professor; Ph.D. 1981, Univ. of Washington

- *At UO since:* 1990
- *Field of Specialization:* Observational Astrophysics
- *Research Interests*: Properties of Galaxies; Large Scale Structure; Low Surface Brightness Galaxies; JAVA based interactive curriculum development
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Are the cows in , or out to pasture?

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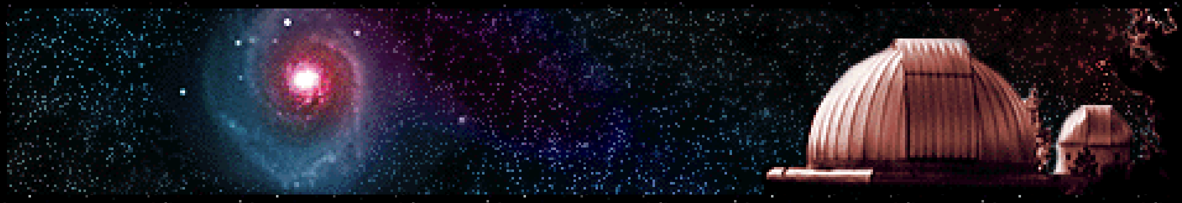
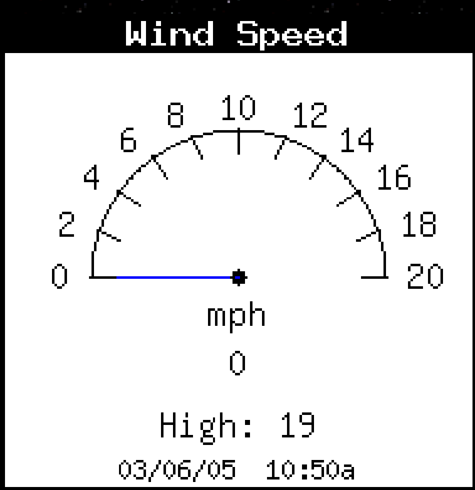
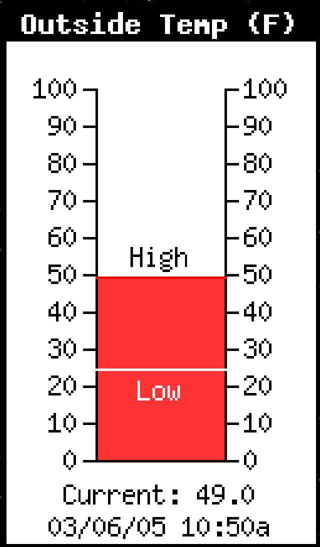


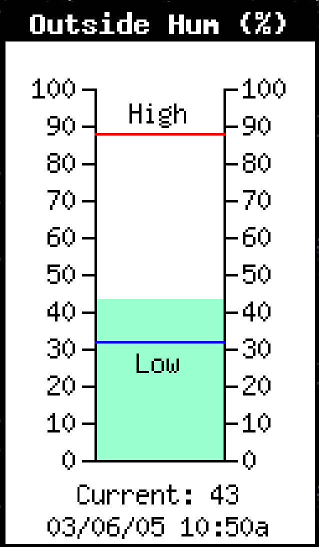
PINE MOUNTAIN OBSERVATORY

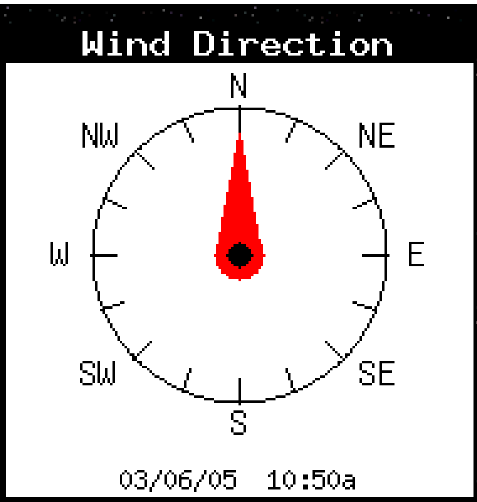
M51 with our New CCD Camera

True color CCD image of M33









[PMO Real Time Weather](http://pmo-sun.uoregon.edu/)

New Web Cams : 24 inch SE View `; 32-inch Control Room ; Pole Cam of Site

The Pine Mountain Observatory is located 26 miles SE of Bend OR which is located in Central Oregon. It is at an elevation of 6500 feet. Telescopes of aperture 15, 24 and 32-inches are there. The facility is operated by the University of Oregon Physics Department. In addition, a group of amateur astronomers, called the Friends of Pine Mountain Observatory , helps to operate the Summer visitors season as well is to visit classrooms during the school year as part of the Observatory's outreach program..

The Prime Focus of the 32-inch telescope now has a 1024x1024 thinned, rear illuminated, blue-sensitive CCD camera which has a field size of approximately 36x36 arcminutes. The system is just now being tweaked and general observing with this camera is about to get underway. Check these pages often for much more information, images and instructions on how to request images. Some representative images can be found here . The telescope still has some tracking problems so the stars are a bit elliptical in this 10 minute exposure. We are working to resolve this.

Our current internet conectivity is now provided by a direct T1 connection with the University of Oregon campus. In addition, there is also wireless coverage on the mountain. This connection leverages the previous infrastructure of the NERO network .

More Information:

- Visitor Information
- Friends of Pine Mountain Page
- Information on August 11-12 Perseid Meteor Shower
- Our 32-inch Telescope
- Read about our Internet Connectivity Project (This is a legacy document from 1994!)
- CCD Images of Some Messier Objects
- Watch an animation of lunar phases (mpeg format)
- NET sites related to Astronomy

The Electronic Universe Project

nuts@moo2.uoregon.edu

Friends of Pine Mountain Education Officer

The CareTaker

- About Friends of Pine Mountain Observatory (including how to visit)
- Image from new COWCAM plus views from New on-site Quick-Cams
- Current & Upcoming Events to Attend
- Current & Upcoming Sky Events/Objects
- Materials for Teachers and Students
- **Classroom Outreach General Overview 2004-2005**
- Pine Mountain Image Current Web Version
- Pine Mountain Image Archived issues
- **Sun-Earth-Moon (SEM) download**
- **Plan a trip to a Planet or Star with JPL's new site**
- Special events you can attend
  - Total Solar Eclipse, 2017

OBSERVING & EDUCATION NEWS/ANNOUNCEMENTS Feb/Mar

Our Outreach operation is funded through NASA's Oregon Space Grant.

Download the latest issue of **The Pine Mountain Observer** here!

Welcome to the FOPMO Archived Images page.

We will begin posting images taken by several Friends of Pine Mountain from PMO 9-19/20-97 plus several other images from this past Spring & Summer. New images will be added as you request them and as we take them.

CCDDOP Images of Objects in the night sky

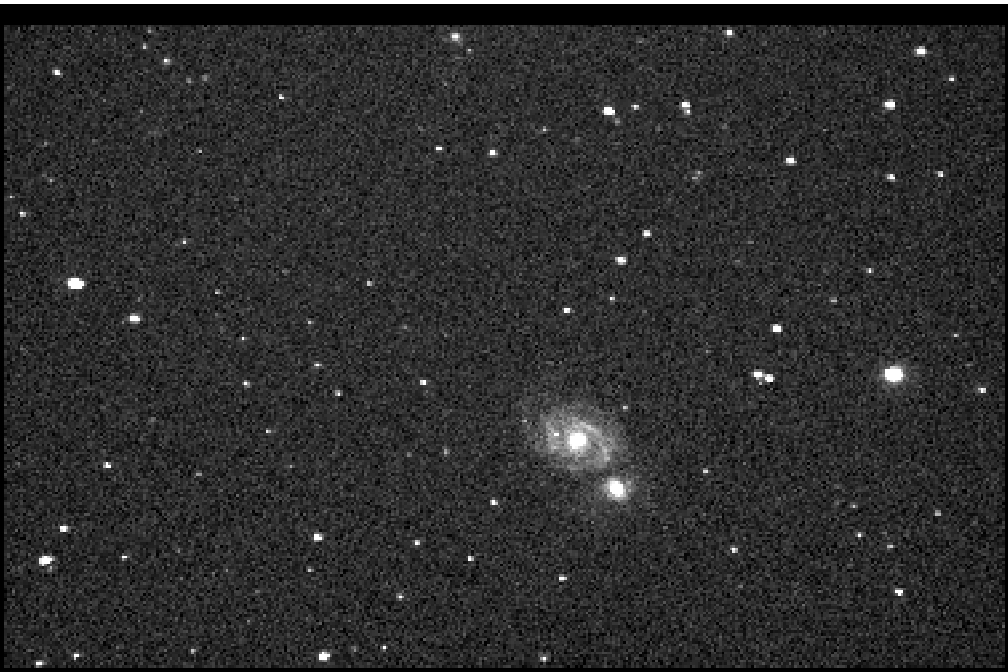
Archived images taken at Pine Mountain, filed by category, name, or Messier number, with date, time, imager and/or requestor listed.

These images are in GIF format and are under 200 KB apiece.

GALAXIES

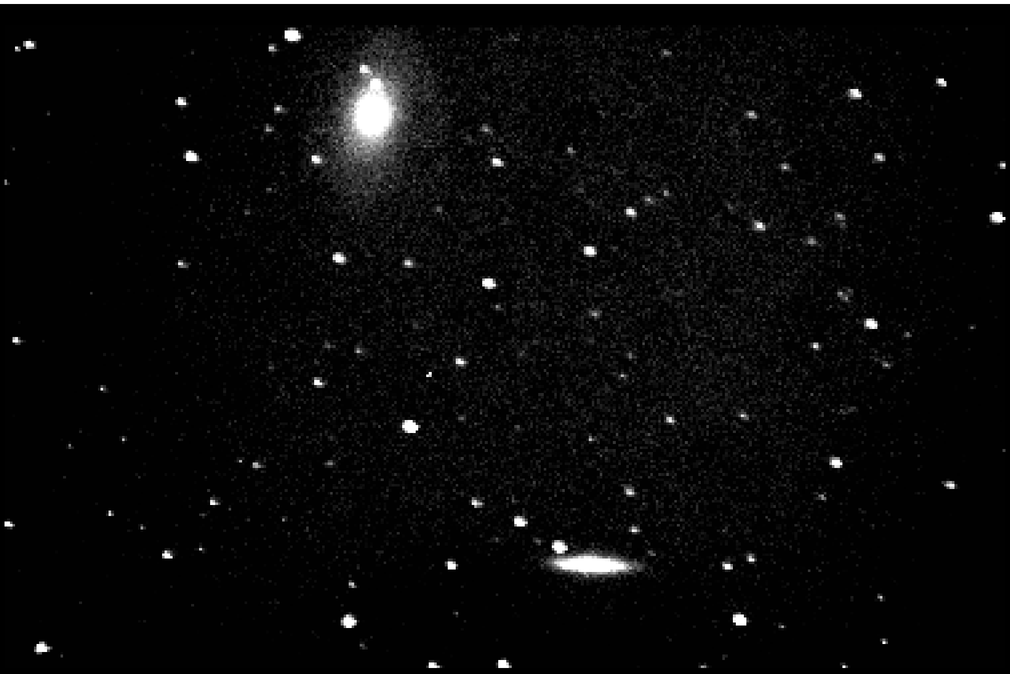
M31, the Great Andromeda Galaxy, plus satellite galaxy M32 above, 8-29-97, 2318, by Rick Kang.

M51, the Whirlpool Galaxy, near the Big Dipper, 7-19-97 , 0120, by Rick Kang



M65, M66, and NGC3628 in southern Leo, 6-8-97, 0034, by Harold & Barb Locke

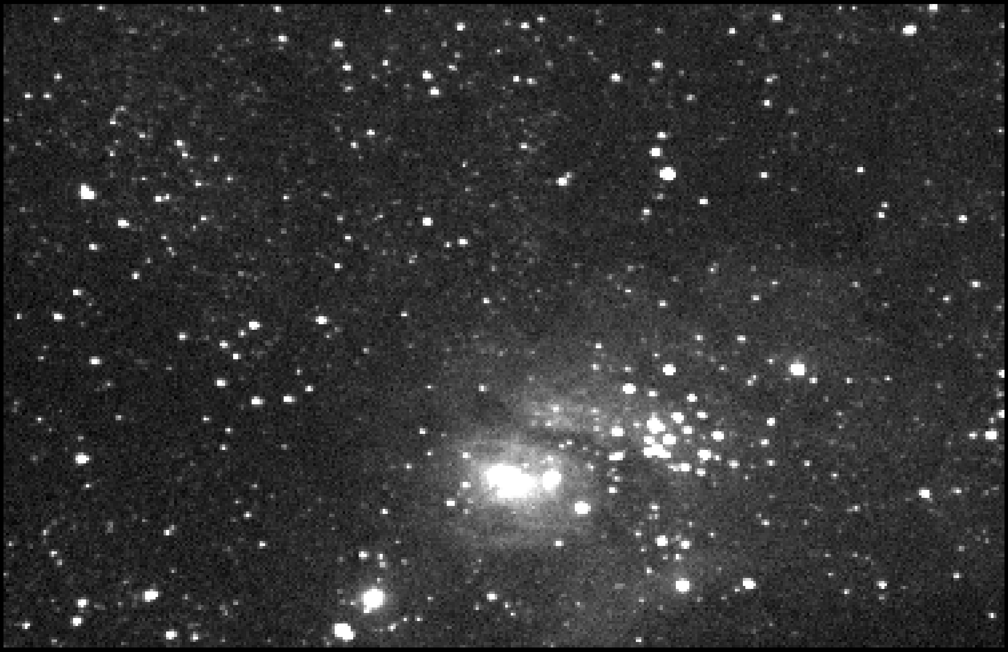
M81, M82 above bowl of Big Dipper, 9-20-97, 0544, by Rick Kang and Nicolas Gulino



M101 above handle of Big Dipper, 6-8-97, 0342, by Rick Kang

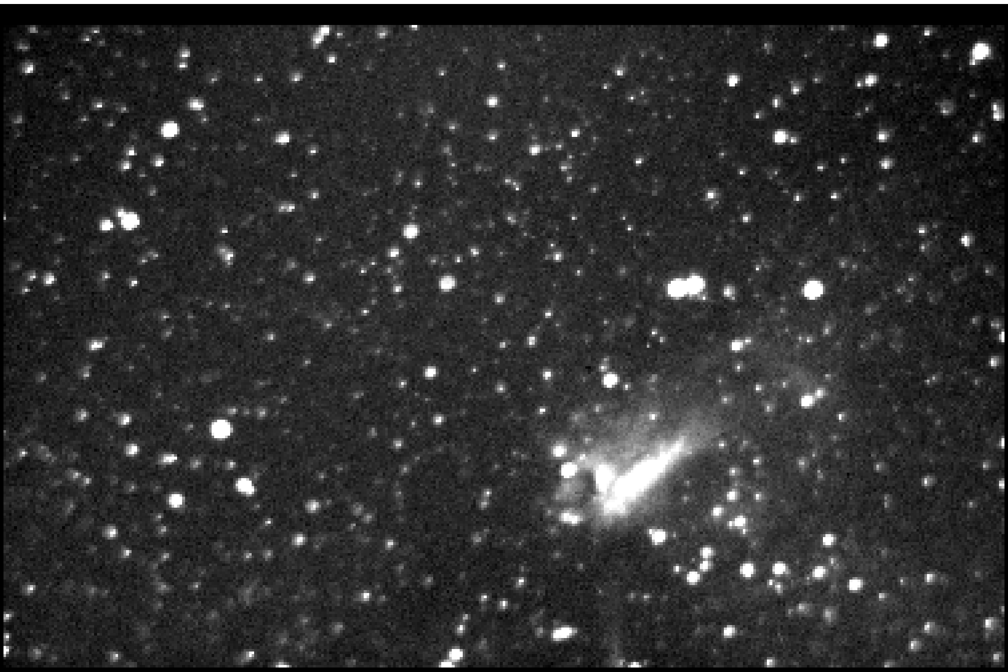
NEBULAS

M8, Lagoon Nebula in Sagittarius, a vast stellar nursery in the Milky Way, 6- 8-97, 0342, by Rick Kang



M16, Eagle Nebula, in Serpens, containing "Elephants' Trunks" of HST fame, 6-8-97, 0248, by Rick Kang.

M17, Swan or Omega Nebula, in Sagittarius, 6-8-9 7, 0256, by Rick Kang.



M42, the Great Nebula below Orion's belt, 9-20-97, 0417, by Nicolas Gulino.

DOUBLE STARS, VARIABLE STARS

OPEN STAR CLUSTERS

M11, Wild Duck Cluster, in Scutum, 6-8-97, 0328, by Rick Kang.

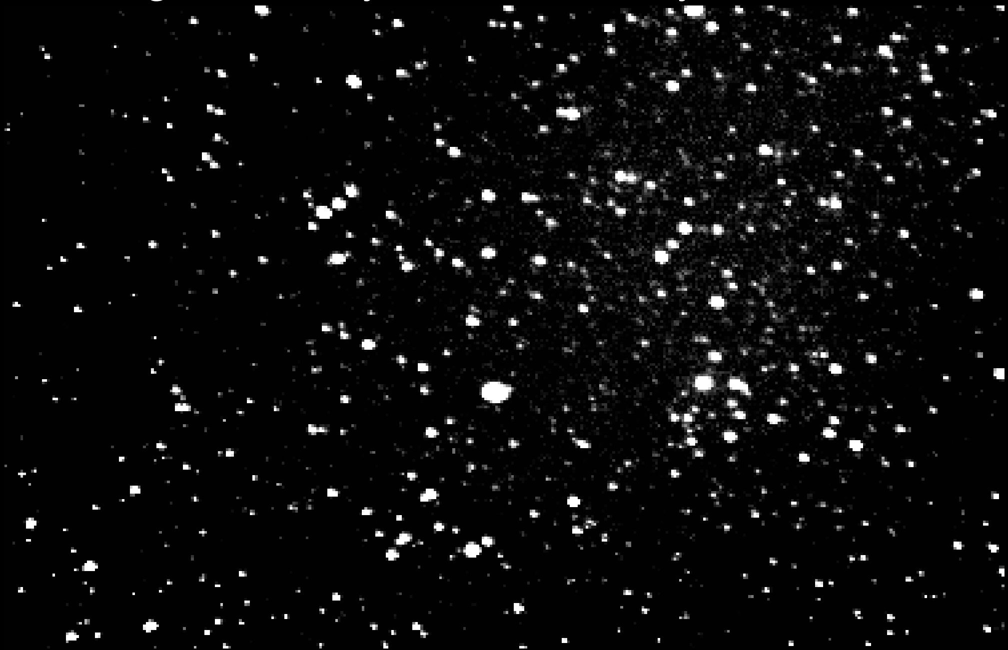
NGC869/884, Double Cluster, in Perseus, 9-21-97, 0552, by Nicolas Gulino.

GLOBULAR STAR CLUSTERS

PLANETARY NEBULAS

M27, Dumbbell Nebula, in Vulpecula, 7-18-97, 2352, by visitor.

M57, Ring Nebula, in Lyra, 9-19-97, 2206, by Barb Shaw.



Bubble Nebula, in Cassiopeia, 9-20-97, 2347, by Rick Kang, Nicolas Gulino.

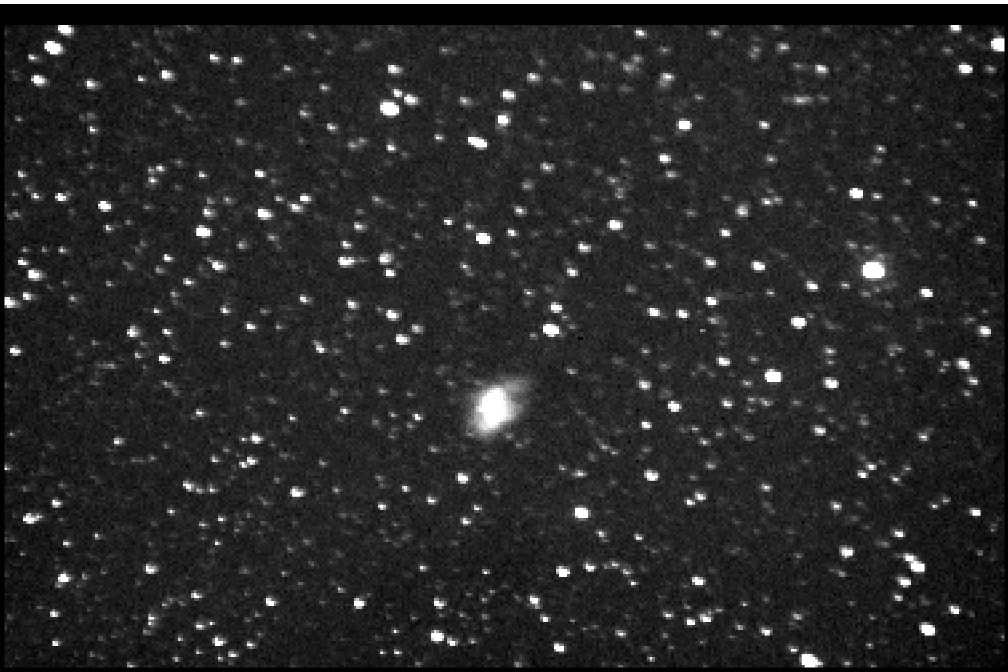
NGC281, in Cassiopeia, 9-20-97, 9-21-97, 0158, by Rick Kang

NGC7293, the Helix Nebula, 9-20-97, 0137, by Rick Kang.

SUPERNOVA REMNANTS

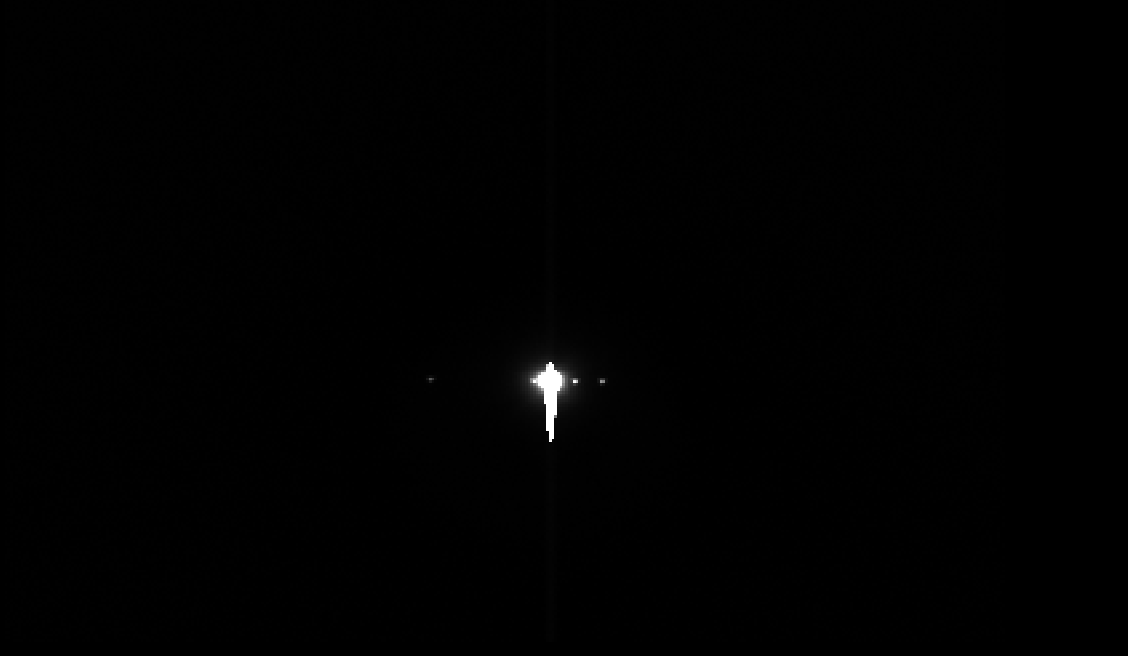
NGC6992, Veil Nebula (portion), in Cygnus, 9-20-97, 0323, by Nicolas and Amanda Gulino

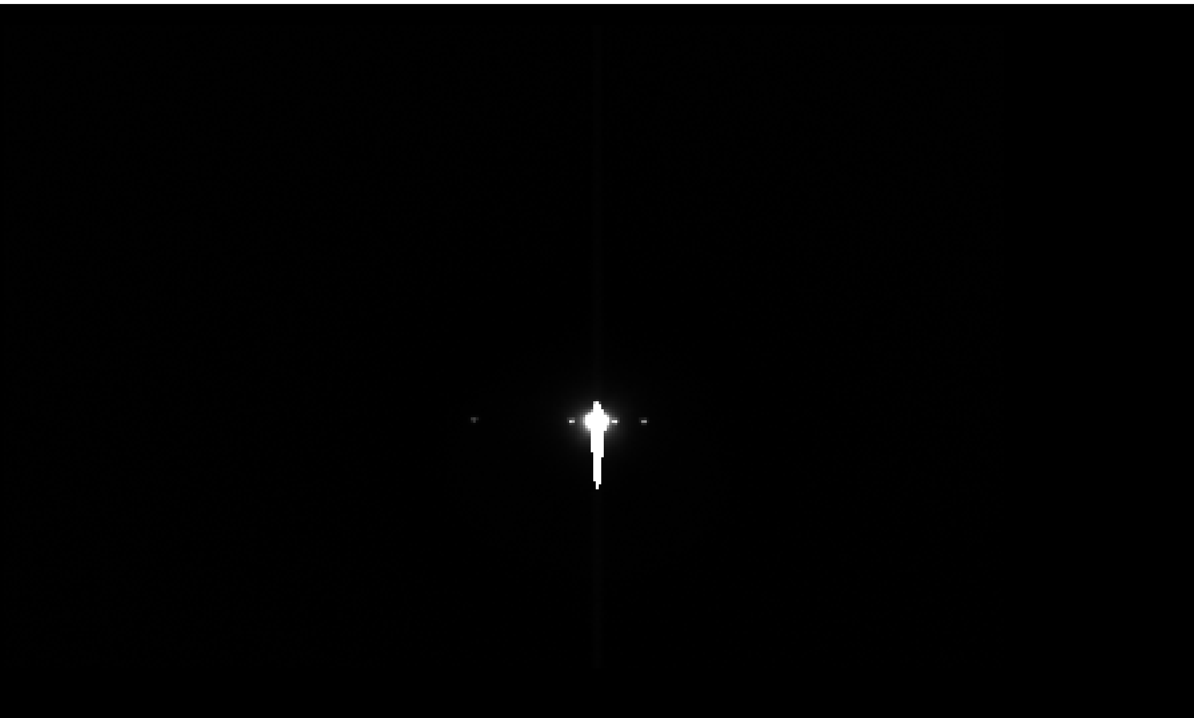
M1, Crab Nebula, in Taurus, 9-20-97, 2347, by Nicolas Gulino



PLANETS, THEIR MOONS, EARTH'S MOON

Jupiter and its large Galilean Moons, at 0020 and 0220, 7-19-97, by student





Saturn and several of its Moons, 8-29-97, 2345, by visitor.

COMETS, MISC. OBJECTS

Star field containing Asteroid Anacostia, at 0132, 8-15-98, and then at 0208, 8-16-98, by Rick Kang and Jim Quisenberry

Can you spot the wandering dot?

This site maintained by The Friends of Pine Mountain Observatory.
If you have any comments or questions please send them to:
Amy McGrew, WebWeaver, or to Rick Kang, FOPMO Education/Publicity Chair

Last updated 20 February 1998.

Details of

EDUCATIONAL OUTREACH PROGRAM for

STUDENTS and TEACHERS presented by

FRIENDS OF PINE MOUNTAIN OBSERVATORY

as of February, 2000

written by Rick Kang, Public Education/Outreach Coordinator
based on University of Oregon's Professor of Physics,
Dr. Greg Bothun's "Electronic Universe" Concept and Technologies

Page 1

MEASURING THE SKY 2000 - An Interactive K-14 Outreach Program
INQUIRY-BASED SCIENCE with an ASTRONOMY THEME
General Concepts/Technologies Created and Suggested by University of Oregon Professor of Physics Dr. Greg Bothun, his "Electronic Universe" idea. (http://zebu.uoregon.edu)

Specific Programs Developed and Presented by
Friends of Pine Mountain Observatory, the citizens' support group of
University of Oregon's Pine Mountain Observatory
Mr. Rick Kang, Public Ed./Outreach Coordinator & Web Author, Eugene,
rkang@efn.org, 541-683-1381
Mr. Nicolas Gulino M.Ed./Outreach Presenter/Developer, Eugene,
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Mr. Bill Arthur, Outreach Presenter/Remote Imager, Bend,
bbarthur@transport.com, 541-593-9718
Ms. Jean Grendler, Outreach Presenter, Eugene,
jmgrendler@uswest.net
Mr. Frank Gornto, Web Weaver, f_gornto@efn.org

CAUTION: There's a lot of stuff on these pages. Don't try to take it in all at once! The actual presentations are very "down to earth", we relate complex ideas to familiar experiences, and will tailor our presentations to your class levels. We've included a lot of information here in an attempt to provide answers to most questions.

OVERVIEW: This is a science enrichment opportunity that uses the content area of astronomy. Our programs work best in the middle of your Space Science unit since the programs encourage students to pursue research. This is our tenth year of outreach to grades K-14. The programs are very interactive, participants are asked to perform a variety of exercises with real technology and data, props, worksheets, and reasoning skills. We cover many science and math CCGs and Oregon Benchmarks.
We also offer staff development programs.

PROGRAMS: Doing Real Science: Acquiring and Analyzing Real Data:
for grades K-3: EXPLORING BASIC CONCEPTS OF SPACE
for grades 4-14: MEASURING THE SKY
two projects with Authentic Digital Data
for all students and teachers: TECHNOLOGY TO EXPLORE DEEP SPACE
Use of CCD Cameras, Telescopes, Pine Mtn. Observatory.
(We fold some or all of this portion into all programs.)
for teachers: TEACHING OREGON's EARTH-IN-SPACE BENCHMARKS,
TEN INQUIRY-BASED DIGITAL OBSERVING PROJECTS,
REMOTE IMAGING WORKSHOPS & OPPORTUNITIES

GOALS:
1. Students will perform real science with real data.
2. Students will operate digital cameras and telescopes.
3. Students will be able to model their large scale environment.
4. Students will describe their connection to their large scale environment.
5. Teachers will have technologies and resources to successfully implement current pedagogies of science education.

FREQUENTLY ASKED QUESTIONS about the outreach programs.
PRE-OUTREACH PREP MATERIALS FOR GRADES 4-14
PREP REFERENCE MATERIAL/VOCAB
PRE-OUTREACH PREP MATERIALS FOR GRADES K-3
EVALUATION FORMS (post presentation) for students/teachers.
Back to the top

FOPMO OUTREACH: FREQUENTLY ASKED QUESTIONS about our programs:

Where do these programs fit within my space science curriculum?

Our overall goal is to design a program that serves you and your students best. Although we have several "canned" segments to save "re-inventing the wheel", we encourage you to discuss your needs. The programs are designed to stimulate ideas.
For Students, we recommend outreach toward the middle of the unit so that students could incorporate what they've learned into a project.
For Teachers, (depending on your comfort level with the subject), we recommend staff development prior to the start of your unit.

How much time do I need to allocate for a program/presentation?

Typically 60-90 minutes. If the class is well prepared, we can do an outreach session in 40-45 minutes, but not in depth.

How big a class can we handle?

20-30 students max for outreach presentations, since there are a lot of interactive activities. "Assemblies" don't work well.
We'd rather do a series of repeat classes.

What do we need for facility/setup?

Typical classrooms work fine. We need as large a screen as possible to project onto, a sturdy table, 3x6 or so, to place laptop, LCD projector, and CCD Camera upon, and access to standard grounded electricity. We need to be able to darken the room, or at least have no direct sunlight streaming in. Basically, we bring all our hardware along.

We need unloading/loading area sheltered from rain, and access to a large rolling cart to move the equipment packets into the classroom. We need about 30 minutes to set up, and 30 minutes to take down.

Since we bring a fair amount of hardware, including telescope and camera, and have fragile equipment, we recommend setting up for the day and scheduling classes to rotate through the one room.

For Staff Development workshops, having Internet accessible, and doing the workshop in a Computer Lab, is ideal.
We can usually demonstrate live remote imaging if your computer is connected via cable to the Internet.

Does the program cost anything?

We are very flexible on fee, except we need to cover travel costs out of the metro area. The program is free for Eugene/Springfield metro area schools and if Mr. Arthur does Bend metro area. Out of metro area, we need $.31 per mile, plus necessary meals/lodging. On outreach exceeding 200 miles round trip we will typically rent a car and need costs covered.
We encourage a $25.00 per class contribution if possible, and for schools

to share costs by scheduling us at multiple sites/trip. ($50 for teacher workshops.) We may request two checks as presenters split revenue with FOPMO. We've done this program as volunteers until this year. We now have a small NASA Oregon Space Grant that pays a small amount per class.

(FAQs continued)

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FOPMO OUTREACH **FAQs continued**

What should I do to prepare my class for an outreach visit?

For grades 4-14, please check the PREP info below, this is very important so that your students will get the most benefit from the presentation.

For grades K-3, just introducing students to the sky, have them consider what the Sun, Moon, and Stars might be, and introduction to basic vocab is fine. The last page of the PREP info below has some specific ideas.

What types of authentic research could my students do?

Projects are up to you and your students to devise, we encourage teachers to attend our Remote Imaging Workshops, we'll probably hold another this Summer. A favorite and fairly simple project is to locate Asteroids and search for new Asteroids. See the REMOTE IMAGING WORKSHOP and INQUIRY-BASED SPACE-SCIENCE links below. See the ARCHIVED IMAGES under the CCD link on the main page for examples of the objects/field you can acquire.

How do I get started, scheduling outreach, etc.?

Contact Rick or any of the other 3 presenters listed at the top.
We generally need two weeks advance notice, longer in the Spring.

Do I have to do any paperwork?

For 4-14 we have optional double-sided worksheets prepared for students. Examples are below at this web site under the MEASURING THE SKY link. We bring masters to duplicate. For all classes, we request that you sign your school onto our register sheet for our Space Grant funding, and that your students complete a brief, half-page evaluation (see below, this could be done as homework or day after), and that you complete an evaluation sheet and return evaluations to the presenter.

Do you have any ESL presenters? Yes! Mr. Gulino is a native Spanish speaker.

Can I bring my class to Pine Mountain Observatory?

Yes, we encourage you to schedule a Field Trip for your class to Pine Mountain Observatory during suitable Fall or Spring weather after the classroom outreach sessions. Contact Property Manager Mark Dunaway, 541-382-8331, markpmo@transport.com, to schedule. There's a virtual tour of the Observatory, first link at the FOPMO web page.

Do you have a newsletter?
Yes! The PINE MOUNTAIN IMAGE, monthly, find current and back issues on the main web page.

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PREP CONCEPTS for grades 4-14 classes:

Please don't be intimidated by all this stuff below,
just glance through it at first, but...

We have found that we can cover a lot more material in a lot more depth if students are familiar with the ideas listed below. Conversely, student feedback indicates that students think "I have no clue what this is all about" if we walk in cold. We can present introductory materials, but then we don't get to the actual science projects and technologies. We'd be glad to help you with the prep materials and have revised/simplified the materials below. There's NO need to cover the technical details, topics such as spectrum, optics, electricity, etc.. We don't get very technical at all unless you want us to. Vocabulary and general concepts are much more important. We really appreciate having classes prepared and thank you in advance for your efforts!

Students should be able to do a "fill in the blank" with each statement and/or illustrate or physically demonstrate the concepts/relationships involved. An instructional activity is included with each section below:

YOUR STUDENTS NEED THREE MAIN CONCEPTS:

1. THE VASTNESS OF DEEP SPACE: (concept of Light-Year)
   - A. If our Sun is represented by a ping-pong ball, Earth would be a pinhead about 9 feet away, Pluto would be a grain of sand about 300 feet away, and the nearest star to the Sun would be about 400 MILES away to scale.
   - B. If our Solar System is represented by a 1/4" diameter paper punch-out, our Galaxy would be a 150 mile wide pancake, (Coast to Bend) and the next major galaxy would be another large pancake, clear across the country, 3000 miles away to scale, in New York City!

   INSTRUCTIONAL ACTIVITY: Make a scale model of the Solar System (for 1" = 1 MILLION MILES, planets are tiny dots, spaced roughly 3, 6, 9, 12, 50, 100, 200, 300, 300 feet away from the Sun (note big gap Mars-Jupiter, and that

Neptune/Pluto cross orbits. Think about the nearest star to our Sun, 400 miles away, roughly in Seattle at this scale!

C. Since light travels so fast, 186,000 miles per SECOND, if we ride a light beam, (PHOTON), for one year, we cover many seconds worth of miles, hence a distance of about 6 trillion miles, which is called a LIGHT YEAR.

D. A beam of light takes almost a day to cross our Solar System, over four years to get to the nearest star, over 100.000 years to cross our galaxy, and millions to billions of years to travel between galaxies!

(prep continued)

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FOPMO OUTREACH - PREP INFO CONTINUED

INSTRUCTIONAL ACTIVITY: Measure distance by timing how long a student takes to walk or run a distance (and knowing the speed of the student). Imagine how far you could bicycle in one year, a "bicycle year", drive in one year, "an auto year", and then how far light travels in one year, a LIGHT-YEAR, a measure of DISTANCE.
Calculate that distance: 186,000 miles/second x 60 seconds/min x 60 min/hour x 24 hours/day x 365 days/year = miles/year.
Note in your scale solar system model above that a student walking slowly between the planets is far exceeding the speed of light!

2. THE HIERARCHY of OUR KNOWN UNIVERSE: (vocabulary)

A. Everything observable is within our UNIVERSE.

B. GALAXIES are huge "star cities", where stars are born, live, and die.

C. NEBULAS are huge clouds of gas and dust within galaxies, stars are formed from this material, and stars dissipate themselves back into it.

D. STARS are generally large very hot spheres of gas. Within stars, atomic nuclei are being fused together to manufacture heavier chemical elements. Thus, stars can be thought of as nuclear chemical factories. In the process, a lot of energy is given off.

E. PLANETS are spheres of rock, liquid, and/or gas that orbit stars.

F. MOONS are bodies of rock or ice that orbit planets.

G. COMETS, ASTEROIDS, and METEORS are debris left over from the formation of a Solar System.

H. A SOLAR SYSTEM is a star, orbited by Planets (which may be orbited by their Moons), Comets, Asteroids, and Meteors.

INSTRUCTIONAL ACTIVITY: Have students envision their city/town as a Galaxy. Their homes are Solar Systems within that Galaxy. Their family members are Planets within their Solar System, and their possessions could represent the

Comets, Asteroids, and Meteors within their Solar System. Where is the next "Galaxy" using this model? Are there any "Stars" between "Galaxies"? The numbers aren't quite right, though, as typical Galaxies have billions of stars. (See scale model under 1.B. above.)

Note that Space is mostly empty. Most of the matter is invisible Dark Matter, apparently surrounding galaxies and clusters of galaxies, and not well understood yet. Gravity from all bodies and from dark matter acts on all other bodies in our Universe, tugging on them, thus making them move.
(prep continued)

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FOPMO OUTREACH - PREP INFO CONTINUED

3. THE NATURE OF LIGHT: (concept of PHOTONS)
   A. Light is created after MATTER is energized and then releases some of that energy as PHOTONS. Commonly by heating matter, but also by adding electrical energy, mechanical energy, or adding other light or other forms of radiation.
   B. PHOTONS are tiny packets of energy, behaving as waves and particles.
   C. You cannot see light unless it literally hits your eye.
   D. Since photons are packets. you can count them and thus measure their incoming strength or brightness.
   (Why might this not be the same as brightness of source?
   E. Our sky is filled with PHOTONS since there are many stars in the sky, and since these stars are hot objects, they radiate lots of PHOTONS.

INSTRUCTIONAL ACTIVITIES
   a. Think of lots of ways to manufacture PHOTONS (there are many varieties of them encountered in daily life, in household, home entertainment, and medical devices and in industry (and of course from our Sun).
   b. Shine a flashlight beam across the room, explain why you don't see the beam but you can see where the beam hits.
   c. Why can't you easily time the travel of photons?
   d. How can you count photons, what could you actually measure about them, since photons themselves are a virtual representation of this matter/energy crossover phenomenon?
   Imagine that each star in the night sky emits M&Ms instead of photons. How could you measure and define the brightness or magnitude of a given star?

Grades 4-14 PREP SUMMARY:
The energy distribution (essentially the amount and direction, and sometimes

the varieties of energy levels (spectra)) of incoming PHOTONS is the specific data that you collect as an astronomer. This is all that you can directly measure! Why photons are sparse, how to collect them, and what you do with incoming Photons to explore your Universe are the subjects of our sessions... The prep is really to describe briefly what photons are, where they originate from, and why their trips to Earth take a very long time.

The critical prep work is that students have an exposure to and grasp the vocabulary, have an insight into the vastness and structure of deep space, and grap the idea of photons.
Technical concepts such as spectra are not necessary at all. The basic ideas can be presented interactively in one period, on an overhead or board. Having pictures of the various types of objects helps. Students already familiar with this material can be introduced to ideas about stellar evolution, from nebula to protostar to proplyd (early solar system) to planetary nebula, or supernova/black hole/neutron star.

Again, don't be overwhelmed by all this material, it's here for your reference. If have questions, please contact Rick.
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PREP/VOCAB/CONCEPTS continued - REFERENCE INFO:

SUMMARY OF RELATIVE DISTANCES (there's a really nice chart of this from NASA under Introductory Topics at our Astronomy on the Internet section of our web page)
Earth-Moon: 2 light-seconds
Earth-Sun: 8 light-minutes
Solar System diameter: roughly 1 light-day
Nearest Stars: several to several hundred light-years
Milky Way Galaxy diameter: roughly 100,000 light years
Distance to nearest big galaxy: roughly 2 Million light years
Typical Galaxy Cluster separations: Billions of light years

SUMMARY of VOCABULARY/BACKGROUND CONCEPTS:
(words in caps are the most important)
(lots of nice pictures, diagrams, explanations at web site)
LIGHT YEAR (DISTANCE a photon travels in one year - ~6 trillion miles)
UNIVERSE/GALAXY/SOLAR SYSTEM/STAR/NEBULA/PLANET/MOON
Energy/Light/Radiation/PHOTON (tiny energy packet of light)
SCALE MODEL - concept of representing large distances by small units
Rotation/AXIS, Revolution/ORBIT/circle/ELLIPSE
Diameter/Radius, SPIRAL shape

ANGLE
REFLECTION/MIRROR/Focus
MATTER/Mass
ATOM/ELECTRON/ELECTRICAL CHARGE/ELECTRICITY
Force/Field/GRAVITY (force (field) created by presence of matter)
ARRAY (grid of numbers)
IMAGE (picture)
CONTRAST (range of light and dark areas in an image)

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FOPMO OUTREACH - PREP INFO CONTINUED - K-3 ideas

Here are some introductory ideas particularly for K-3:

Particularly for younger students, who are often unaware of the environment of deep space, this may be helpful to understand why we cannot readily fly out there and operate successfully without advanced technologies, most of which we don't have yet, and will cost many dollars:

1. No air/atmosphere to breathe, no lift/fuel (oxygen) for aircraft.
2. Very cold (no atmosphere).
3. Need radio to communicate (no sound waves/no atmosphere)
4. No readily available supplies, food/water,etc.
5. Lots of dangerous radiation, high-speed particles, debris flying around. Some planets/areas have toxic chemicals, and/or are too near to stars for life (too hot, too much other radiation)
6. Huge distances! This is the major deterrent! Have students imagine taking a flight from the local airport higher and higher. What goes wrong with conventional aircraft? What does the sky look like and feel like? How long would you need to fly to get to the Moon, Planets, Stars, Galaxies? What would you need to get you there?

Some major misconceptions associated with the above include:

1. The sky stays blue (turns to black several dozen miles up, as you run out of air that scatters the blue light). (try shining flashlight through beaker of pure water, then repeat after clouding water with few drops of milk, that simulate atmosphere.)
2. Gravity disappears (Earth's gravity pulls on you less, but gravity doesn't stop abruptly, just fades out, and we are under influence of gravity of other bodies, too...any mass dictates gravity...the strength of gravity on you depends on? (mass, distance!)). Do you exert any pull on the Earth? Sun? "Thought Experiments about Gravity":
   a. What happens if we drop a baseball down a long tunnel that has been dug clear through the center of the Earth?
   b. Could your spaceship to the Moon remain stationary without power at

some point, balanced between Earth and Moon's gravity?

c. What would eventually happen to two spheres placed several feet apart in deep space, far from any galaxies or other mass?

Another fun exercise for youngsters is to figure out how much they'd weigh if they are standing on the Moon, other Planets, or the Sun.

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FOPMO OUTREACH - EXPLORING BASIC CONCEPTS OF DEEP SPACE:
SAMPLE SYLLABUS FOR K-3 CLASSROOM OUTREACH:

1-2 hours, using digital images, props - Inquiry-Based
Topics selected from list by teacher for grade level, knowledge, interests.

1. What shape is Earth? How do you know? Model.

2. Why are Planets/Moons/Stars globes? (Sandbox idea)

3. Why do Planets/Moons/Stars/Galaxies rotate (spin)?
   What daily observation gives you an idea that we are spinning?
   (Angular momentum "dance" exercise)

4. What is the Sun? What are Stars? (Characteristics)

5. What are Planets and Moons? What is a Solar System?
   (scale models exercise: rotation/revolution, solar system)
   (distances concept ideas: an imaginary trip) (lots of pictures)

6. What is another common feature of Stars, Planets, even Galaxies?
   Why do these disks/rings form? (Example of making pizza)

7. Why does the Moon change "phase"?
   (Light, Shadows, Viewpoints exercise)

8. What are the Constellations? Are stars at various distances?
   (Ways to measure distance/visual evidence)

9. The movement of the sky: What do you observe changes hourly, nightly?
   (Solar System Planet Step exercise, Classroom Planetarium)

10. The Galaxy: a collection of Solar Systems. Other galaxies: star cities.
   ("transparent school" thought exercise to visualize galaxies of students)

11. Introduction to Light/Viewing Objects in Deep Space:

Exercises: Flashlight beam: Photons you can't always see-
Experiments with reflection, shadows
How to make photons (daily experiences)
What happens to photons from distant stars
(walk-out from curved table exercise)
Interaction of photons with matter:
Emission/Reflection/Absorption/Transmission
(student photons, student wall)
How we "see" Stars, Moon, Planets,
what we can't readily see, and why.

Keep in mind your direct connection to objects in space:
How do the Sun, Moon, Planetary Environments, Nature of
Stars, and Nature of Galaxies relate to our daily lives?

Experience taking images with the CCD,
Experience looking through telescope

Photo tour of Pine Mountain Observatory
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FOPMO OUTREACH - MEASURING THE SKY
SAMPLE SYLLABI FOR GRADES 4-14 CLASSROOM OUTREACH

We offer two INQUIRY-BASED programs, that use authentic data:
ASTROMETRY (positional measurements) and
PHOTOMETRY (brightness measurements).

Both programs include introduction to CCD/Telescope technology,
and conclude with models that demonstrate the vastness and
organization of deep space.

We start with a quick introduction to Pine Mountain Observatory
including a photo tour. We also touch briefly on the relevance of
astronomy to daily life, why the subject is a study requirement.

The pairs of worksheets are directly below, two sheets for each program.
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MEASURING THE SKY Modern Astronomy in the Classroom 1999-2000

ASTROMETRY **Side 1 of 2**

by Rick Kang, Pub. Ed./Outreach Coordinator - Friends of Pine Mtn. Observatory
rkang@efn.org http://pmo-sun.uoregon.edu/~pmo/

OVERVIEW: To make discoveries, ASTRONOMERS use technologies to collect and measure PHOTONS from the sky to investigate the large-scale environment, the nature of objects far, far away. Due to current digital technologies, you can directly participate in this exploration.

GOALS: After our session, you will be able to:
1. Measure positional data and use this data to model deep space.
2. Diagram/explain how CCD Camera works, why astronomers use this technology.

SESSION DETAILS:
1. Science Question: DO OBJECTS IN THE SKY MOVE (relative to one another)?
Your Hypothesis:

2. Experiments: OBSERVATIONS: How can we measure the position and a change of position of objects in the sky?

We could see if an object moved by ___________ ___________ _____________.

Our DATA is in the form of PHOTONS. Stars emit ______ . (Because stars are so

_______ .) First we need to ________ and make a ________ of those photons.

3. Introduction to the Technology to Collect & Detect Photons from Deep Space:
Telescope and CCD (digital) Camera:
Problem:
Dealing with the "few and far between" PHOTONS (of starlight): (2 methods)
THE PHOTONS ARE THE DATA!
Photons are "few and far between" because they _________ ______ over space!

Two methods to collect photons: Name of actual technology:
a.

b.

4. Experience with a CCD (Charge Coupled Device) Digital Camera:

a. A Photo-Electric Cell converts incoming ____________ energy into

an equivalent amount of free _________________ .

b. To create an image, the CCD (grid of photo-electric cells) does two things:

1. Accumulates data in the equivalent form of ______________.

2. _______________ the electrons in each cell,

to make a _________________ image.

Therefore, we can easily MEASURE the brightness and __________ of each pixel!

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MEASURING THE SKY **Modern Astronomy in the Classroom** **1999-2000**

ASTROMETRY **Side 2 of 2**

5. PROJECT:

Observations: Compare same star field, images 24 hours, then 3 hours apart.

a. Do you observe/measure any Astrometric (positional change) of any objects, RELATIVE TO ONE ANOTHER, over periods of time?

What changed? Can you devise a hypothesis about why this happened?

b. Figure out the Relationship that describes why some objects APPEAR to move more than others: (What FACTOR is the "proper motion" RELATED to?) (If you discover several factors, which factor may be most significant?)

Object's Proper Motion is_________________to Object's__________________.

Conclusions: (relate to your Hypothesis and to your Observations)

Relative movements of objects in the sky___________________________.

Such observed motion may be due mostly to the object's______________

and therefore may be used to determine the object's_______________.

Error Sources: What might lead to incorrect measurements?

Implications of the relationship:

Models about structure and depth of space from your Conclusions: Can you describe Three "Ballparks" or Zones of Deep Space defined by apparent motion?

Class of Objects: Apparent Relative Motion:

6. Three reasons people who collect data like CCD Cameras/Digital Data:

a. The CCD is very ____________________ to photons. (efficient at recording)

b. Digital images can be ______________________ and ______________________.

c. Digital images are easy to ____________, _____________, _____________, and are therefore easy to _____________ with your associates.

7. A view into really deep space: Hubble Deep Field images:
The farthest any human has yet seen into space!

Please ask questions during class or via E-mail.

You are encouraged to design a remote imaging project during the school year and to visit Pine Mountain Observatory during the summer!

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MEASURING THE SKY **Modern Astronomy in the Classroom** **1999-2000**

PHOTOMETRY **Page 1 of 2**

by Rick Kang, Pub. Ed./Outreach Coordinator - Friends of Pine Mtn. Observatory
rkang@efn.org http://pmo-sun.uoregon.edu/~pmo/

OVERVIEW: To make discoveries, ASTRONOMERS use technologies to collect and measure PHOTONS from the sky to investigate the large-scale environment, the nature of objects far, far away. Due to current digital technologies, you can directly participate in this exploration.

GOALS: By the end of our session, you will be able to:
1. Measure brightness data and use this data to model deep space.
2. Diagram/explain how CCD Camera works/why astronomers use this technology.

SESSION DETAILS:

1. Science Question: (background: What is a STAR?)
   ARE ALL STARS THE SAME BRIGHTNESS? (In appearance and physically)

   Your Hypothesis:

2. Experiments: OBSERVATIONS: How can we measure the brightness of stars?
   Our DATA is in the form of PHOTONS.
   Stars emit _______________ . (Because stars are so _______ .)
   We need to ________________ and ___________________ those photons.

3. Introduction to the Technology to Collect & Detect Photons from Deep Space:
   Telescope and CCD (digital) Camera:

Problem:

Dealing with the "few and far between" PHOTONS (of starlight): (2 methods)

THE PHOTONS ARE THE DATA!

Photons are "few and far between" because they ___________ ______ over space!

Two methods to collect photons: Name of actual technology:

a.

b.

4. Experience with a CCD (Charge Coupled Device) Digital Camera:

   a. A Photo-Electric Cell converts incoming ____________ energy into

   an equivalent amount of free _________________ .

   b. To create an image, the CCD (grid of photo-electric cells)
   does two things:
   1. Accumulates data in the equivalent form of ______________.

   2. _______ the electrons in each cell,

   to make a _________________ image.

Therefore, we can easily MEASURE the position and ___________ of each pixel!

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5. PROJECT:

Observations: The seven stars of the Big Dipper: What do you observe
Photometrically about each star (compare brightness of stars)?:
Use laptop to measure authentic archived images of these 7 stars.
Write the measured value under each star.

```
   Alkaid     Alcor/Mizar
      o            o    Alioth
                           o
                              Megrez            Dubhe
                                o                  o
Units of measure:
Possible error factors:         Phecda            Merek
                                   o                o
```

POSSIBLE MODELS TO EXPLAIN YOUR DATA:

a. Factors/Relationships that influence how bright the star APPEARS to us:

1. A star may look brighter because the star is _____________________.

2. " " " " " " " " " _____________________.

3. " " " " " " " " " _____________________.

4. A star may look brighter because there may be less __________________

______________________________.

b. If we model the Big Dipper Star Cluster in 3D, which above factor is most significant in our modeling of distances to the stars?

Conclusions: (Relate the measurements/relationships/model to your hypothesis):

Stars____ in brightness.
We can measure ______________to determine ___________________________.
Implications of the relationship:
Constellations are made up of stars at various ____________________ .
Also,
In the foreground you might find __________ _____________ objects.
In the background you might find many other _________________.

6. Three reasons people who collect data like CCD Cameras/Digital Data:

a. The CCD is very ______________ to photons. (efficient at recording)

b. Digital images can be __________________ and ______________________.

c. Digital images are easy to ____________, _____________, _____________,

and are therefore easy to _____________ with your associates.

7. A view into really deep space: Hubble Deep Field images:
The farthest any human has yet seen into space!

Please ask questions during class or via E-mail.

You are encouraged to design a remote imaging project during the school year and to visit Pine Mountain Observatory during the summer!

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FOPMO OUTREACH - EVALUATION (post-presentation)
EVALUATION from STUDENTS

1. Describe and/or draw and label one idea or concept or fact that you learned from the presentation:

2. What did you like best about the presentation?

3. What didn't you like? How could we improve the presentation?

4. If you could visit an object in deep space, anywhere in our Universe, and return tonight to Earth, where would you travel to?

5. What's your most important question now about astronomy?

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FOPMO OUTREACH - EVALUATION (post-presentation)
EVALUATION from TEACHERS - post presentation

Your Name:

School: Grade levels:

1. Did this presentation meet your expectations? Please explain your answer.

2. Did we give you enough information about the presentation beforehand?
If not, please explain what information you lacked.

3. Were you able to prep your students sufficiently?
If not, please explain what you needed to accomplish better prep.

4. What were the strongest points about the presentation?

5. What were the weakest points? How should we change the presentation?

6. What are the most critical resources/information/technologies that you currently lack in order to create the most effective lessons about astronomy for your class?

7. Would a class field trip to a Planetarium and/or Observatory be useful/feasible?

We are contemplating setting up a summer Astronomy/CCD Camp for students who have particular interest in Space Science/Technology. Please keep a note of candidates of your students, we'll contact you Spring, 2000.

Thanks! (return forms to Rick Kang, 1534 Ranchwood Dr., Eugene, OR 97401)

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FOPMO OUTREACH - TECHNOLOGY TO EXPLORE DEEP SPACE - WORKSHEET

TELESCOPES & CCD CAMERAS P.1 of 2 Rick Kang

1. "Light Travel Time" to Moon: Sun: Pluto:
   Other Stars: Neighbor Galaxy: Other Galaxies:

2. a. Examples of radiation: a.   b.   c.
   (types of PHOTONS)

   b. Sketch starlight (PHOTONS) moving out into space, and indicate how many PHOTONS might hit OBSERVER A versus OBSERVER B:

```
                             |
                             | OBSERVER A
STAR  *                      |
                                          |
                                          | OBSERVER B
                                          |
```

   To which Observer does the star look BRIGHTER?
   Why?

3. What "tools" would help us gather more faint starlight?
   (What two principles can we use to gather "few and far between "PHOTONS"? Think about collecting RAINDROPS!)

4. Let's build a TELESCOPE. Diagram what we build, how it works:
   Note the three essential parts and what they do.
   Show the path of a ray of light from entering the telescope to exiting into your eye.

   What's the main purpose of an astronomical Telescope?
   (in terms of how we want a very distant object to appear)

   What really makes a Telescope more powerful?

   Diagram how Magnification works. Why don't astronomers always use high power (magnification) optics? 3 reasons:

   Why do Astronomers generally use Reflector style telescopes instead of Refractors?

   How far away can any Telescope collect light from?

Why can't you really see that far into space with
your eye through a Telescope?

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FOPMO OUTREACH - TECHNOLOGY TO EXPLORE DEEP SPACE - WORKSHEET
TELESCOPES & CCD CAMERAS P.2 of 2 Rick Kang

5. When you take a picture with a CCD Camera, what conditions do you notice about the production of the picture? (Bright or dim target, long or short exposure, amount of time to produce the result, etc.)
   a.

   b.

   c.

6. What can we do with the Digitized Image? (Can we store the image, improve the image, if so, how?)
   a.

   b.

   c.

   d.

7. What type of ENERGY (power) goes INTO a PHOTO-ELECTRIC CELL?

   What type of ENERGY (power) comes OUT of a PHOTO-ELECTRIC CELL?

   When we INCREASE the light falling on the cell, what happens to the power that the cell puts out? (MORE light = ? power)

   (Fill in the blanks:) A CCD CHIP is an ARRAY of__________ ________ CELLS. Each cell converts incoming______________into an amount of________________. This amount is sent to the computer as ______________ . Therefore, the computer "thinks" of a picture as a string of _____________ . Each digit represents how __________ or ___________ to "paint" that PIXEL on the computer screen. Thus, we call such a "picture" a ______________ image.

8. What two specific measurements from each PIXEL in an image can be made about that corresponding tiny area of the sky?

9. Three MAJOR advantages of using a CCD Detector (Camera) and digitized images when exploring FAINT objects, far away (astronomy):
   a.

   b.

   c.

10. What does any CAMERA do with incoming light, that your EYE does NOT do with that light?

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FOPMO OUTREACH - TEN INQUIRY-BASED DIGITAL OBSERVING PROJECTS - Sheet 1 of 2

by Rick Kang, Public Ed./Outreach Coordinator
Friends of Pine Mountain Observatory   September, 1999

The following projects involve various types of observations and math, and can all be adapted to K-14 levels. CCG areas of observing, measuring, changes, cycles, systems, uncertainties, making models and predictions, and use of technology apply to all of the projects, and specific Earth-in-Space Benchmarks apply to several of the projects.

All projects become INQUIRY-BASED upon Framing the Question about the topic in each Description area listed.

1. Brightness of Objects, Reasons for Variations in Brightness:
   Description: Explore variations in brightness over a population of stars, and over periods of time.
   Model some explanations, relate to our Sun.
   Data: Digital images or visual (stars of a Constellation).
   Background topics: Light, Vision, Stars, Stellar evolution, Variable Stars, AAVSO
   Math: Comparing, Relationships, Inverse square law, Ratios, Graphing

2. Rotation of a Planet:
   Description: Analyze series of photos/images of Jupiter.
   Determine what you see and what you can

calculate about Jupiter. Relate Jupiter to Earth.
Data: Photo provided by Meade Instrument Co.
Background topics: Measuring Time, Solar System, Meteorology
Math: Comparing, Ratios, Geometry of circles, Angles, Angular measurement, Equations of motion

3. Colors of Objects:
Description: Observe, describe colors of objects in the sky, explore reasons for the various colors, relate to colors observed on Earth of various substances at various temperatures.
Data: Naked eye observations, Telescopic/Digital observations
Background topics: Temperature, Chemistry, Spectra, Geology, Stars/Stellar Evolution
Math: Relationships, Graphs, Wave Properties, Equations like e=hv

4. Changing Appearance of our Moon:
Description: Make log of lunar phases/location/cycle, make predictions
Data: Naked eye observations
Background topics: Time, Moon, Orbits, Light: Shadows & Reflections
Math: Geometry, Telling time, Graphing

5. Objects in Motion - The Moons of Jupiter:
Description: Observe the motions of Jupiter's Galilean Moons, Determine orbital parameters, make predictions. Compare to Earth-Moon system.
Data: Digital or Telescopic Optical Observations
Background topics: Solar System, Kepler's/Newton's laws
Math: Ratios, Angles, Conic sections, Equations of motion (continued)

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FOPMO OUTREACH - TEN INQUIRY-BASED DIGITAL OBSERVING PROJECTS - Sheet 2 of 2

by Rick Kang

6. Relative motions of objects - Finding Asteroids and Comets:
Description: Search for asteroids and comets in the ecliptic. Attempt to identify the object and to characterize its motion/location. Assess the threat of these types of objects to Earth.
Data: Series of Digital Images, comparisons
Background topics: Solar System, Ecliptic, Near-Earth-Objects, Mass Extinctions (of life)
Math: Ratios, Coordinates, Angles, Conic sections, Equations of motion

7. Angular size vs. Distance:
   Description: Explore relationship of angular size to distance.
   Estimate distance to a galaxy by this means.
   Data: Digital images
   Background topic: Galaxies
   Math: Angles, Proportions/ratios, Functions, Trigonometry

8. Depths of Space:
   Description: Analyze series of images of increasing exposure.
   Determine why the picture changes and what you might see
   by increasing exposure, and also the associated problems.
   Data: Series of digital images
   Background topics: Hubble Deep Field, Photography, CCDs
   Math: Counting, Arrays, Digitizing, Inverse square law, Statistics, Averaging

9. Sky Survey by Zones:
   Description: Analyze series of images taken over various
   zones of the sky. Classify and determine
   counts of objects.
   Background topics: Stellar Evolution, Galaxies, Milky
   Way, Large Scale Structure
   Math: Counting, Statistics, Graphing, Angular/Area Measurement

10. Sky Motions/Ecliptic:
   Description: Record positions of objects in sky over
   a period of time and at different times during
   night and day. Explain the evident motions,
   model what you see, make predictions, locate
   the Ecliptic, relate day and night, monthly
   events, seasonal/annual events observed from
   Earth to motions/orientations of objects
   in sky relative to Earth.
   Data: Naked eye observations
   Background topics: Solar System, Time, Orbits, Seasons,
   Constellations, Shadows
   Math: Measuring angles and time, Graphing, Equations of motion.

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FOPMO OUTREACH - TEACHING OREGON's EARTH-IN-SPACE BENCHMARKS Rick Kang 1999

We will use observational methods to visualize/explore/teach the concepts of
relationships of Earth-Moon-Sun in space and how the orientations and motions
of these objects account for what we see in our daytime/nighttime sky.
We will relate how the celestial motions define our measures of time.

HAVE STUDENTS KEEP AN OBSERVING LOG RIGHT AWAY! SKETCH THE SKY!

1. Is the Earth a Globe? How can you prove this?

2. Observing from "Mount Nose": Your head as the Earth.
   Your outstretched arms as your "Horizons". Which is East/West?
   Where is your "Zenith"? Where is your "Meridian"?

3. Obvious changes in appearance of the sky as the hours go by:
   Does Earth rotate? Evidence? Rate? What is the "Polar Axis", "Equator"?

   Which direction does Earth rotate? (Use model from item 2 to demo)

4. Why do the stars/star patterns (constellations) appear to move/change?
   What is moving, relative to what?
   How far away are various objects in space? Use Scale Models.

   Does Earth revolve (orbit) the Sun? Evidence? Rate?
   Which direction does Earth revolve? Build Classroom Planetarium.

5. Why does the Moon change "phase" and position in sky? Observe model of
   phases of Earth, use the Moon on a Stick exercise. Use your Mount Nose
   observation model to predict rise/set, location, phase (2-person team).
   Does the Moon orbit Earth? Evidence? Rate?

   Why do Eclipses occur? Why don't they occur monthly?

6. Why do we experience Seasons?
   What creates atmospheric heat? Nature/distance of Sun.
   What factors govern amount of radiation received on the ground:

   Observed variations in these factors: Use light on Globe model.
   (Illuminated thermometers in pans of water may also work.)

   Is Earth's axis perpendicular to the plane of the Solar System(Ecliptic)?
   Does Earth tip back and forth? Evidence? Visiting Santa- the North Star.
   Views from Arctic Circle, Tropics of Capricorn/Cancer.

7. Motions in the Solar System: Wanderers amongst the "fixed stars"
   Why do the Planets appear to wander? (planet-step exercise)
   Are Planets confined to a particular zone of the sky? Why?

   Appearances of "Inferior" vs. "Superior" Planets, predicting where
   to find planets: Item 2 model, Orrery model. "Retrograde" motion.

   Which direction do the planets orbit the Sun? Do they all revolve at the same speed? 4 ways to identify a planet in the sky.

Refer to http://pmo-sun.uoregon.edu/~pmo/ for more info/projects.
Thanks to Andy Fraknoi, Nicolas Gulino, Dennis Schatz, Tim Slater, and other astronomy educators for ideas/tips used in this paper.

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FOPMO OUTREACH - REMOTE IMAGING WORKSHOP **Rick Kang**
COWCAM and CCDDOP OPERATION

We encourage all teachers to get involved with our remote imaging operation. You can facilitate an authentic research project by your students. Their data will be digital images from cameras mounted on telescopes at Pine Mountain Observatory. (Other digital data/camera resources are available on the web, but we are one of the few that offer inexpensive quality live imaging.)

Through an IDEAS grant from the Hubble Space Telescope Science Institute, we have some funding to conduct workshops for teachers and provide software for schools to connect to the Observatory to take images/acquire data.

Workshops train teachers about
1. the hardware/software at the Observatory.
2. theory and practice of digital imaging, enhancing and analyzing images.
3. telecommunications hardware/software.
4. nature of objects in deep space and how to locate objects.
5. feasibility of imaging various objects/phenomena.

Teachers involved can then work with students to enable students to
1. Select specific research projects.
2. Select specific targets to image.
3. Arrange schedule for remote imaging.
4. Acquire, analyze, display, and store data.
5. Present a completed research project.

We held a three day seminar in Bend the summer of 1999 where 14 teachers, grades 4-14, from around Oregon, were involved. We held a second seminar last Fall, in Albany, devoted to image analysis software. So far, students have been restricted by weather and time constraints, and software compatibility issues (this latter issue is being resolved, particularly for the MAC platform situation).
We are also awaiting re-mounting of Professor Bothun's COWCAM, the extremely high quality camera, at prime focus of the 32" telescope. This camera will have UVBRI filters, and is envisioned as the prime research tool for

students.
Meanwhile we continue taking data as weather allows, using our pilot CCDDOP project ST6 camera piggybacked onto the 24" telescope, imaging through a 90 mm Maksutov lens.
Both systems give a one-degree square field of view, see the CCD link on the FOPMO web page for details about the CCDDOP project and to view archived images.

We will post information about future workshops and about student project results here.

Currently, Ms. Helix Fairweather, Astronomy Instructor at Linn-Benton Community College, has used the CCDDOP system to locate several known asteroids, contemplates having her students search for new ones, and wants to help PMO become a certified reporting station for the Minor Planets Center.

Mr. Ray Kaser, of Silverton High School, has students mapping images of open star clusters with eventual goal of determining if our Sun is a member of a cluster.

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CCD Images of Messier Objects:

Note: This is a secondary mirror site of the main messier archive located here . If you find some images missing here then go there.

These objects were discovered in the 18th century and were catalogued so that eyeball observers using small telescopes would not confuse them with comets. With the naked eye as a detector, most of these objects appear as dim grayish blobs. They are considered a challenge to find for many amateur astronomers. These objects are generally of large angular size and hence larger than the typical field of view of many CCD detector systems; hence CCD images of these objects are somewhat rare compared to photographic ones. In this resource, we offer CCD images of many of these objects, taken with a variety of different telescopes, along with a description or narration of brief facts about them. Where appropriate we have linked additional images or diagrams to further explain their properties or structure.

Messier Objects 1-9:

- M1 image -------> More About M1 Nice Color Picture
- M2 image -------> More About M2
- M3 image -------> More About M3
- M5 image -------> More About M5
- M8 image -------> More About M8 Nice Color Picture

Messier Objects 10-19:

- M13 image -------> More About M13
- M15 image -------> More About M15
- M16 image -------> More About M16

- M17 image -------> More About M17

Messier Objects 20-29:

- M20 image -------> More About M20
- M27 image -------> More About M27

Messier Objects 30-39:

- M31 image -------> More About M31 Nice Color Picture
- M33 Image and Information

Messier Objects 40-49:

- M42 image ; M43 image -------> More About M42/43 Nice Color CCD Picture

Messier Objects 50-59:

- M51 image --------> More About M51 Color Image of M51 M51 Supernova
- M57 image --------> More About M57 --> Nice Color CCD Picture --> Very Deep M57 Image

Messier Objects 60-99:

- M61 image ---------> More about M61
- M63 image ---------> More about M63
- M64 image ---------> More about M64
- M81 image --------> More About M81 M81 Supernova --> Ultraviolet Image of M81 ---> More about Ultraviolet Imaging
- M82 image --------> More About M82 M82 False Color M82 True Color
- M83 image --------> More About M83
- M87 image --------> More About M87 M87 Jet
- M90 image --------> More About M90
- M91 image --------> More About M91 Infrared Image of M91
- M95 image --------> More About M95

Messier Objects 100+:

- M100 image --------> More About M100 ---> HST Restoration Image
- M101 image --------> More About M101

The Electronic Universe Project
e-mail: nuts@moo.uoregon.edu