Star Dust

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Lockman to Talk on the New Green Bank Observatory

Nancy Byrd

The next meeting of National Capital Astronomers is on December 5, 1992 at 7:30 PM at the National Institutes of Health (in the Bunim Room on floor 9 of the Clinical Center (Building 10). At this colloquium, Dr. Felix J. Lockman will speak on the subject of the National Radio Astronomy Observatory (NRAO) at Green Bank, West Virginia.

As many of you know, the Green Bank Observatory had long functioned as one of the world's leading radio observatories until its unfortunate collapse, which occurred a few years ago. The facility is currently under reconstruction. We look forward to Dr. Lockman telling us about the construction of the new facility; lessons learned with the first instrument, including what will be repeated in the new; what new designs are to be used; and what interesting plans now exist for the observatory's use.

Dr. Lockman received his B.S. in 1970 at Drexel University, and his Ph.D from the University of Massachusetts. Except for a two year stint as a Postdoctoral fellow at the Department of Terrestrial Magnetism of the Carnegie Institute of Washington, Dr. Lockman has been associated with NRAO since 1972, when he began by serving in the Summer Intern Program. He has since progressed through a variety of positions, reaching his present position as Project Scientist, Green Bank Telescope.

Judith Lean Talks on Solar Variability and Global Change

By Nancy Byrd

On the November 4, 1992 meeting, Dr. Judith Lean treated NCA to another excellent lecture on the subject of solar variability, but on this occasion she also explored the implications of solar variability for global climate change.

Dr. Lean began with a review of the bulk measurements of the Earth and Sun. The Sun's blackbody temperature of 5770K peaks in the visible part of the spectrum, while that of the earth is 255K, and the Earth, heated by the Sun, radiates energy peaking in the infrared region of the spectrum. (The earth is considerably warmer than its blackbody temperature due to its greenhouse gases.) It is the interplay of these two radiation signatures which drives the Earth's climate.

Dr. Lean and her colleagues have separated their consideration of changes in energy from the Sun into three parts: The first and primary part is changes in total solar irradiance, energy integrated over the entire spectrum or over the familiar blackbody curve. Most of this heats the Earth directly. The second, ultraviolet radiation, is absorbed by the atmosphere (the ozone layer), but can also affect climate indirectly. The third, solar particles and plasma radiation, primarily affecting the upper atmosphere, was not discussed.

We can think of changes in the Sun's total irradiance as a

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December Calendar

The Public is Welcome!

Saturday, December 5, 9:30 AM - James Sharp (NASM), "Stargazing for Beginners," at Smithsonian Institution, National Air and Space Museum (NASM) Albert Einstein Planetarium.

Saturday, December 5, 5:30 PM - Dinner with the speaker at Frascati's Restaurant in Bethesda before the monthly meeting. Reservations are for 5:30 Sharp!

Saturday, December 5, 7:30 PM - Felix J. Lockman (National Radio Astronomy Observatory), "The New Green Bank Observatory." Meeting will be held in the Bunim Room at the National Institutes of Health. For directions refer to map and description on inside back page.

Friday, December 4, 11, 8:30 PM - NCA 14-inch telescope open nights with Bob Bolster, 6007 Ridgeview Drive, south of Alexandria off Franconia Road between Telegraph Road and Rose Hill Drive. Call Bob for details and more dates at (703) 960-9126.

Wednesday, December 9, 4:30 - 8:30 PM - Total Lunar eclipse viewing at Patuxent River Park in Prince George's County, MD. While there is no charge, reservations are required. Call (301) 627-6074 for details and reservations.

Friday, December 11 - Viewing of close passage to Earth by asteroid 4179 Toutatis with NCA Celestron 14 at Ridgeview Observatory, Alexandria, VA. For details and more dates call Daniel Costanzo at (703) 841-4765.

Monday, December 21, 7:00 PM - "The Day of the Sun's Return, the Winter Solstice," at Montgomery College's Planetarium. Information: Dr. Harold Williams, (301) 650-1463 (o) or (301) 565-3709 (h).

Next Month:

Saturday, January 9, 1993, 7:30 PM - Voyager at Neptune. Please mark your calendars; because of the New Year holiday, the meeting will be held on the second Saturday of the month.

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"forcing" of the Earth's system says Dr. Lean; it heats up the oceans and the land. The Earth's surface re-radiates. Much of the Earth's radiation is absorbed by CO_2 ; so if you change the total solar irradiance or the amount of CO_2 in the atmosphere, you apply a forcing to the climate system which must then readjust to a different equilibrium.

There are many such climate forcings. Greenhouse gases cause an increase of temperature. Volcanos and aerosols also apply forcings of Earth's climate, because their presence in the upper atmosphere can reduce the amount of radiation reaching the surface. Changes to the Earth's albedo from, say, deforestation or desertification can affect how much energy is reflected back into space. Moreover there are numerous feedbacks in the system. For instance, if you increase the total solar irradiance, this might increase evaporation which might then reflect more radiation. Global circulation models must take all these forcings and the feedback mechanisms into account.

The reason that global change has become so important is that there is major concern that anthropogenic changes are causing forcings at such a rate that the system may be out of control in a way that will affect the welfare of human beings. This concern is the major impetus of study. But to understand the effect of the anthropogenic forcings, one must also understand the natural forcings. Understanding the effect of changes in the sun is a part of that. In 1982, Jack Eddy, who established the existence of the Maunder Minimum, a time almost entirely without sunspots on the Sun, chaired a National Academy of Sciences panel on the effect of solar variability on the Earth's climate. The panel's conclusion was that it could have an effect. 1982 was the peak of solar cycle 21, and now we are at the peak of solar cycle 22. Since 1982, we have had quite precise instruments on satellites. So we have had a decade of good measurements of the sun's total irradiance, and good measurement of ozone and other climate parameters.

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Dr. Lean showed us charts of solar maxima and minima based on the carbon 14 record, one going back to the Maunder minimum, and one showing data over a much longer time period. It was such data that formed the basis for the solar panel's conclusion, but at that time it was not clear how good the carbon 14 record was as an indicator of solar variation. Historical charts based on the carbon 14 record have now been validated by the beryllium 10 record as being good indicators of long term solar activity.

Temperatures during the Maunder minimum were 1° cooler than now. During this period (1645-1715) sunspots were rare. We have maintained a good sunspot record from this period to the present time. This record with its 11 year periodicity is strongly correlated with the global temperature anomaly. Although variation in solar irradiance is somewhat different for different parts of the spectrum, changes in the overall solar irradiance, centered in the visible region, dominate the energy picture. The mean total solar irradiance is 1367.54 W/m^2 . Based on observations from four satellites (ERB, ACIM, NOAA9 and ERBBS), Dr. Lean and her colleagues calculate that variation over a solar cycle 21 to 22 translates to 1.2 W/m^2 variation on Earth. This translates to a change of temperature 0.06° to 0.21°. On the other hand, the change in the global temperature anomaly since the turn of the century is about 0.5°C. From solar variation alone one would expect no more than ~0.2°C. This within cycle solar variation cannot explain the observed temperature change.

Longer term carbon 14 data show that there have been other minima besides the Maunder minimum. In fact, the sun appears to have spent about one third of its time in these minima, which we believe to be times when the sun did not cycle. How could you produce these larger changes in temperature preserved in the carbon 14 record? Two possibilities arise: (1) Our global circulation models are not sensitive enough, and smaller changes can produce larger temperature variation. (2) The Sun has changed more than we think (more than 0.1%).

There is evidence that both may be true. David Rind of Goddard Space Flight Center, using NASA's Global Circulation Model, attempted to reproduce the ice age conditions predicted by the Milankovich forcing of climate (due to the Earth's elliptical orbit, its wobble and precession). He could not reproduce the ice ages. This raises questions about the sensitivity of the model.

Ca Fraunhofer lines, H and HK, in a band centered at about 393 nanometers, can be used to study both the Sun and other stars. If you look at these wavelengths, you look at the chromosphere. Images of the Sun show at solar minimum that not only are the sunspots gone (seen at visible light), but also the bright faculae (seen in Ca light) are missing. Now sunspots tend to reduce radiation, because they are dark. But sunspots are small and compact relative to the faculae. Thus the faculae contribute the greater change in energy by their comings and goings. Also visible in Ca light is a lacy network of bright areas known as the chromospheric network, which is present even at the minimum of the solar cycle. If this feature goes away, there would further reduction in insolation of the Earth.

Looking at other G type stars besides the Sun in Ca H and K lines, you can plot the distribution of stars with particular levels of calcium emission. Dr. Lean and her colleagues find that the Sun at present time is among the brightest. They also find that the distribution is bimodal, falling into a group at the level of the sun or less and another group at a much lower level. The higher level group are the middle-aged, cycling stars, where the

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DID ANYONE SEE THE PEEKSKILL METEORITE FALLING?

by John Graham

The fall of the Peekskill meteorite was widely observed in the eastern United States on October 9 in the evening. Dr. George Wetherill, a colleague of mine at the Carnegie Institution of Washington, is presently engaged in determining an orbit for this unusual event and would very much like to hear from anybody who can give a precise timing of a visual sighting or who (better still!) may have a video record of it. He would also be interested in hearing from anyone who is aware of possible reports to police or aviation authorities about the event. Dr. Wetherill's phone number is (202) 686-4375. Alternatively, I am at (202) 686-4403 during the day and (301) 654-0842 at night.

The Gamma-Ray Sky

by Wayne H. Warren Jr.

At the monthly meeting on October 3, National Capital Astronomers were treated to a very interesting and informative talk entitled *Pulsars, Quasars, and Bursts - Results from the Compton Gamma-Ray Observatory*, given by Dr. David J. Thompson of the Laboratory for High Energy Astrophysics at the NASA Goddard Space Flight Center. Dr. Thompson is a Co-Investigator for the Energetic Gamma-Ray Experiment Telescope (EGRET), one of the four instruments on board the space observatory (known as GRO).

Dr. Thompson first addressed the question of why it was scientifically valuable to build and fly an observatory that only works in the γ-ray region of the spectrum, which extends between energy ranges of approximately 30 keV (about 0.05 nm) to >30 GeV (about 0.00000005 nm) and is one of the broadest bands in the electromagnetic spectrum. Although Earth's atmosphere is opaque to γ rays, interstellar and intergalactic space is quite transparent at these wavelengths; thus, we can detect γ rays that have traveled great distances across the cosmos. Because they are produced by highly energetic processes, γ rays can be used to study the most extraordinary objects in the universe. Indeed, previous satellites, such as SAS-2, COS-B, and the HEAO series, which contained more primitive γ-ray detectors, showed that observations were possible and that bizarre objects were detected. Since the γ-ray region is so broad, multiple instruments are necessary to detect and analyze the incident radiation. Thus, the GRO carries four instruments that work in slightly different (with overlap) parts of the spectral band.

The GRO was launched by the space shuttle Atlantis on April 5, 1991. Weighing about 16,000 kg and measuring approximately 21 meters across with its solar panels extended, this second of NASA's "Great Observatories" is one of the largest and heaviest satellites ever flown. Although its tape recorders that stored data for subsequent relay to the ground have failed, the observatory is still operating well and observations are being transmitted directly via NASA's Tracking Data and Relay Satellite System (TDRSS). The four instruments on GRO are the Burst and Transient Source Experiment (BATSE), the Oriented Scintillation Spectrometer Experiment (OSSE), the Imaging Compton Telescope (COMPTEL), and the EGRET. These γ-ray instruments are much more like the particle detectors of high-energy physics than they are like optical telescopes, since γ rays can neither be reflected nor focused, but can only be "detected." A diagram of the instruments showed that COMPTEL detects γ rays of about 1-30 MeV and EGRET works in the range 20 MeV to 100 GeV. COMPTEL detects radiation via the phenomenon of Compton (or Modified) scattering, which involves the interaction of incident radiation with a top set of detectors where the scattering occurs between the incoming photons and electrons in the detectors. A lower set of detectors then measures the scattering angles to produce a circular area on the sky from which a γray originated. Improved direction is determined by overlapping rings, which eventually locate sources. So, while fields of view (FOV) are very large, resolution is small and many detections are needed to observe the objects of study. OSSE operates in a lower energy range (longer wavelengths) and has a narrower FOV, but includes a collimator to restrict the range of detected γ rays. BATSE is completely different from the other instruments in not having an FOV at all. Instead, it

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lower level group (0.24% below mean) did not cycle. Moreover, about one third of the stars were non-cycling, which would be consistent with one third of the time spent in a non-cycling state. A change of irradiance of 0.24% from the Maunder minimum to present time translates to from 0.2°C to 0.6°C. This can explain some but not all of the observed 1°C change.

The ultraviolet component of the spectrum is only 1% of the total solar irradiance, but it varies by 10% (rather than 0.1%) from maximum to minimum, but the energy is all absorbed above the Earth's surface in the upper atmosphere. Ozone is created by destruction of molecular oxygen, the products of which then combine with O_2 to form ozone. TOMS data from the ERB(Nimbus 7) show that ozone abundance has a strong annual cycle. Once this annual cycle is subtracted, a reduction remains which correlates with the 1.5% decrease due to CFCs.

From the Secretary

Any member who subscribes to Sky & Telescope (S&T) through the NCA is entitled not only to the discount on his S&T subscription but also to ten percent discounts on other items ordered from Sky Publishing Corp. Under our new contract with S&T, NCA members can now order books and other products at discount prices directly from Sky Publishing. It is no long necessary to order these through the NCA Treasurer. The 1993 Sky Publishing catalogue and order form were inserted into the November issue of S&T. In order to obtain your discount, indicate on the order form that you are a member of the Club Discount Plan. You automatically become a Club Discount Plan member by subscribing to S&T through the NCA or any other astronomy club.

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Please mail me your dues promptly after you receive my bill so that you will receive your copies of Star Dust and Sky & Telescope on time. If you renew your membership after the expiration date, you may be omitted from one edition of the NCA directory, which is updated only about four times a year. Please do not wait until renewal time to notify me of any changes of address or telephone numbers so that I can keep the directory up to date. Requests for changes of address for S&T mailings, however, must be made directly to the magazine, accompanied by a recent mailing label, except when it is also time to renew your subscription. Then changes can be made on the S&T renewal notice before sending this to us. Thanks.

Leith Holloway, NCA Secretary
Phone: 301-564-6061

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has a set of eight detectors pointed in different directions to cover the entire sky. It looks for photons of varying energy; i.e., for bursts and transients.

The broad program to be carried out by the observatory consists of a full-sky γ-ray survey (already 90 percent complete), followed by pointed observations made by individual scientists as part of a Guest Investigator program.

Dr. Thompson next discussed the observations that have been made to date. One of the first areas examined was the region toward the galactic anticenter (Taurus and Gemini), in which a number of γ-ray sources were observed. One is our old friend Messier 1 (the Crab Nebula), which is always one of the first sources to be observed by new instruments in any wavelength range. The object of interest here is, of course, the pulsar, which is a neutron star rotating at 30 times per second. The other object, which had been seen with previous satellites, is known as Geminga, and had been an enigma until its mystery was solved by combining GRO observations with those made in the X-ray region of the spectrum. Geminga turns out to be a γ-ray pulsar also, but rotating at 4 times per second. It has been well-established that pulsars spin down with age. We know that the supernova of 1054 A.D. produced the Crab pulsar, while the Geminga pulsar is estimated to have been created by a nearby (about 100 ly) supernova that occurred about 300,000 years ago and would have produced an object of visual magnitude about -12 (as bright as the full Moon) in the sky of our ancestors.

Burst and transient phenomena were described next. Gamma-ray bursts vary considerably in intensity and duration, some lasting only 5 milliseconds and others for as long as a minute. Early interpretation attributed these bursts to star quakes caused by surface readjustment as a pulsar spins down, or by collisions between other objects, such as comets, with a stellar surface. Because these bursts were found to have a random distribution on the sky, the neutron stars would have had a uniform distribution within about 100 parsecs of the Sun. The increased sensitivity of the BATSE instrument (about a factor of 10) resulted in the prediction that its observed distribution would not be uniform, since more distant bursts would not be seen perpendicular to the galactic plane where the disk is only a few hundred parsecs thick. However, the bursts detected with BATSE also turn out to have an isotropic (although not homogeneous) distribution, implying an extragalactic origin. Thus, the BATSE observations discount the neutron-star origin and another expla-

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nation must be sought. Now for three-dimensional space, if these bursts originate uniformly from all directions, the number of counts should increase as the -1.5 power of the intensity; i.e., as we go toward fainter bursts, the count should increase ($n \propto I^{-3/2}$). The plotted data show agreement with this prediction for more intense sources, but the observed count deviates below the predicted curve for fainter ones. This implies that there is a cutoff at some radial distance from the solar system, but because we cannot determine distances for the bursts, we have no idea how far out the distribution ends. One problem with the cosmological distance interpretation is that prodigious amounts of energy are required to produce bursts emanating from such great distances. The nearby hypothesis also has problems because the bursters are seen only in the γ-ray region and not at other wavelengths, as would be expected for nearby sources. One possibility for obtaining definitive information is if we can observe γ-ray lines from bursters that could be used to determine redshifts, but such lines have not been observed so far.

Finally, Dr. Thompson discussed GRO observations of quasi-stellar objects (QSOs), also known as quasars. Earlier observations by the European satellite COS-B had detected γ rays coming from the Virgo region that were eventually determined to be from the nearest QSO, 3C273. Surprisingly, the GRO instruments did not see 3C273, but did detect strong γ-ray fluxes from the much more distant QSO, 3C279. Although four times more distant than 3C273, this source turned out to be almost as strong as the Crab, while varying on a timescale of days. Since a point source can only vary on a timescale equal to its size, the variability tells us that the object can be no larger than a few light days across. At an estimated distance of 6×10^9 ly, the energy output is staggering. If such a source is radiating isotropically, its energy output is about 10^4 times that of our entire Milky Way galaxy, and from an object only 2 light days (about 9 solar systems) across. Since this seems physically impossible, the conjecture is that the radiative output is not isotropic, but beamed. The current model consists of a supermassive black hole that is accreting material and producing jets, of which one is directly in line with Earth. If this is the case, then other similar sources should be seen and Dr. Thompson presented a list of sixteen active galactic nuclei (AGNs) that have been detected by GRO instruments. Thus, it appears that we are indeed seeing the output of the most extremely energetic (and luminous) objects in the universe and that many of these objects are at cosmological distances.

To close his presentation, Dr. Thompson discussed the future work of NASA's second Great Observatory. As mentioned earlier, following the completion of the all-sky γ-ray survey, a guest investigator program of pointed observations will be undertaken. During this period, anyone can submit a proposal to use the observatory. Proposals are peer-reviewed by an allocation committee and the best-judged projects are granted observing time. The development of an archive for GRO observations is also in progress at the Compton Observatory Science Support Center at GSFC; thus, all GRO observations will eventually become available to secondary investigators. The GRO instrument teams also plan collaborative observations, continuing data analysis and interpretation, and theoretical work to explain in more detail the origins of the various γ-ray phenomena observed. With an expected lifetime of 10-13 years, we can expect to see many more exciting observations and possibly some solutions to long-standing questions in high-energy astrophysics come from what is certainly an eminently successful NASA mission.

NCA WELCOMES THESE NEW MEMBERS!

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SERVICES AND ACTIVITIES:

A Forum for dissemination of the status and results of current work by scientists at the horizons of their fields is provided through the monthly NCA Meeting. (See monthly *Stardust* for time and location.) All interested persons are welcome; there is no charge.

Expeditions frequently go to many parts of the world to acquire observational data from occultations and eclipses which contribute significantly to refinement of orbital parameters, the coordinate system, navigation tables and timekeeping. Other results of this work under continuing study include the discovery of apparent satellites of some asteroids, discovery of apparent small variations in the solar radius, and profiles of asteroids.

Discussion Groups provide opportunities for participants to exchange information, ideas, and questions on preselected topics, moderated by a member or guest expert.

Publications received by members include *Sky & Telescope* magazine and the monthly publication of NCA, *Star Dust.*

The NCA Public Information Service answers many astronomy-related questions, provides predictions of the paths and times of eclipses and occultations, schedules of expeditions and resulting data, assistance in developing programs, and locating references.

The Telescope Selection, Use, and Care Seminar, held annually in November, offers the public guidance for those contemplating the acquisition of a first telescope, and dispels the many common misconceptions which often leads to disappointment.

Working Groups support areas such as computer science and software, photographic materials and techniques, instrumentation, and others.

Telescope-Making Classes teach the student to grind and polish, by hand, the precise optical surface that becomes the heart of a fine astronomical telescope.

NCA Travel offers occasional tours, local and world-wide, to observatories, laboratories, and other points of interest. NCA sponsored tours for comet Halley to many parts of the southern hemisphere.

Discounts are available to members on many publications and other astronomical items.

Public Programs are offered jointly with the National Park Service, the Smithsonian Institution, the U.S. Naval Observatory, and others.

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The following information is optional. Please indicate briefly any special interests, skills, vocation, education, experience, or other qualifications which you might contribute to NCA

Thank you, and welcome!

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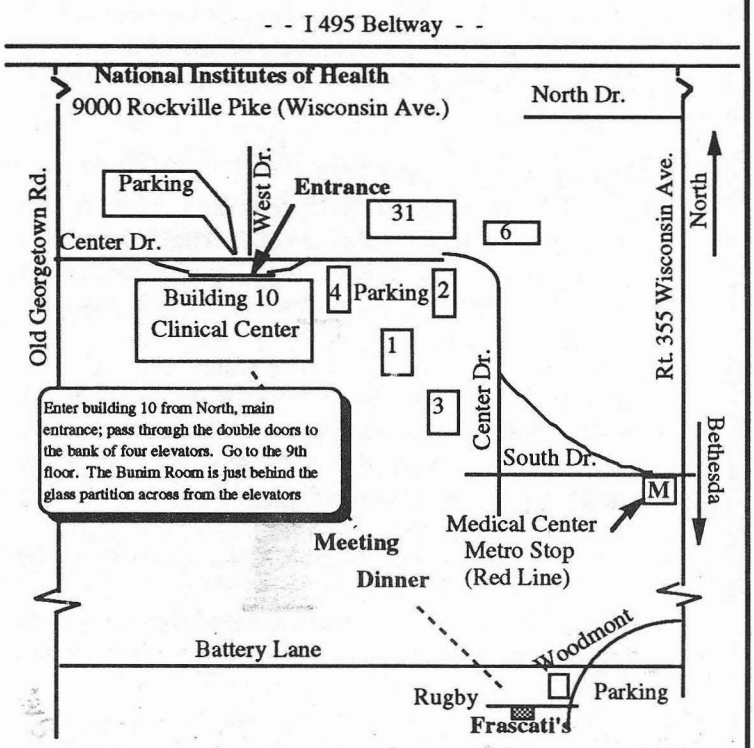
Getting to the NCA Monthly Meeting

•Subway Riders - From Medical Center Metro Stop: Walk down the hill, pass the bus stops and turn right at the anchor (onto Center Drive). Continue uphill to building 10, the largest building on campus. Also, the J2 bus line connects the Bethesda (7:16 PM) and NIH (7:23 PM) Metro stops with Building 10 (7:25 PM).

•To Frascati's: Proceed down Wisconsin Avenue toward Bethesda. Bear right onto Woodmont (or the next right onto Battery Lane), follow Woodmont across Battery, take a right onto Rugby and park. The restaurant will not guarantee seats after 5:30.



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