Star Dust

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LeRoy Doggett to Describe and Demonstrate the U.S. Naval Observatory's Multiyear Interactive Computer Almanac (MICA)

By Wayne H. Warren Jr.
(including an abstract by LeRoy Doggett)

The next meeting of the National Capital Astronomers will be held on June 4, 1993 at 7:30 PM in the Lippsett Amphitheater, Room 1C114, of the Clinical Center (Building 10) at the National Institutes of Health. At this special seminar, U.S. Naval Observatory astronomer LeRoy Doggett will describe the newly completed MICA software package and demonstrate its use. MICA provides the PC and Mac user with the capability to compute much of the data available in the Astronomical Almanac directly on his or her own machine. Thus, it effectively makes 10 years of the AA available at a user's fingertips. For this presentation, we intend to use a computer terminal and screen projection system so that the demonstration can be easily viewed by everyone. The following summary was provided by Dr. Doggett.

MICA - the Multiyear Interactive Computer Almanac - is the latest generation of software packages prepared by the Nautical Almanac Office of the U.S. Naval Observatory. Unlike the programs that present graphical displays of the sky, MICA is concerned with providing the most accurate positions of celestial objects. It incorporates the most rigorous and accurate models of planetary motion currently available. This talk will discuss the problems of accurate astronomical calculations, with historical context.

Dr. Doggett also provides some biographical information, which I will leave in his own words:

"I grew up in Marshalltown, Iowa, where, by fate or chance, an amateur astronomy group sprang up just as I was discovering astronomy as a high school student. I received a BS in Astronomy from the University of Michigan and a PhD, with concentration in celestial mechanics, from North Carolina State University. I have been in the Nautical Almanac Office since 1965, serving as Chief of the Office from September 1990 through May 1994. My research has centered on methods of calculating planetary orbits and on the history of astronomy."

Having known and worked with the developers of MICA for a number of years, and after being a beta tester for the package, I can attest to the fact that the programs are very accurate, useful, and easy to operate. Using these programs, anyone with a PC or Mac can compute planetary ephemerides, rise and set times, and many other useful quantities in a few seconds in the comfort of one's home, in the observatory, or anywhere else that might be convenient. Come and join Dr. Doggett to learn about the history of making accurate astronomical calculations and how these techniques have developed to the point where we can all do the most complicated almanac computations quickly and easily.

Please keep in mind that, as a regular feature of the NCA's June meeting, we will feature the winners of our 1994 Science Fair Awards, which we present annually for what we judge to be excellent contributions in the field of astronomy. This year's winners include Caleb Fassett of Washington Grove, MD; Lascalles Linton of Wheaton, MD; Cedric Lyles of Washington; Sandra Martinka of Springfield, VA; and Justin Sands of Vienna, VA. We hope that all of these students will be able to attend the meeting to display and discuss their projects.

June Calendar

The Public is Welcome!

Fridays, June 3, 10, 17, and July 1, at 7:30 PM - Telescope making classes at American University, McKinley Hall Basement. Information: Jerry Schnall, 202/362-8872.

Fridays, June 3, 10, 17, and July 1, 9:30 PM - Open nights with NCA's Celestron-14 telescope with Bob Bolster, 6007 Ridgeview Drive, south of Alexandria off Franconia Road between Telegraph Road and Rose Hill Drive. Call Bob for details 703/960-9126.

Saturday, June 4, 1994, 5:30 PM - Dinner with the speaker and Science Fair winners at Shakey's (East-West Highway and Wisconsin Avenue) before the monthly meeting. See the map on the back page of this issue for directions. Reservations are for 5:30PM sharp.

Saturday, June 4, 1994, 7:30PM - Dr. LeRoy E. Doggett will speak on "MICA and the Art of Astronomical Computing." Meeting will be held in the Lippsett Auditorium at the National Institutes of Health. For directions, refer to map and description on back page.

Tuesdays, June 7, 14, 21, and 28, 7:30 PM - Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 202/362-8872.

Saturday, June 11, 9:00 PM - "Exploring the Sky," telescope viewing at the open field in Rock Creek Park nearest to the Nature Center. NCA members please bring telescopes. For more information, see article on page 3 and call John Lohman, 703/820-4194.

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Hubble Space Telescope Results on Star Formation in Other Galaxies

Reviewed by Wayne H. Warren, Jr.

At its May 7, 1994 meeting, members of the National Capital Astronomers and guests were pleased to hear a lecture by Dr. Sara R. Heap of the Laboratory for Astronomy and Solar Physics, NASA Goddard Space Flight Center, concerning her own and others' research on star formation using results from the Hubble Space Telescope (HST).

Dr. Heap began her presentation by pointing out that the HST is an observatory for use by all astronomers who wish to compete for telescope time on the basis of proposal evaluation by a peer review allocation committee. Although time is far oversubscribed and, thus, the process very competitive, the observatory is used by more than 200 researchers per year and has already contributed new fundamental knowledge in virtually every field of astronomy.

The three basic questions concerning star formation that researchers would like to learn more about with the HST are: (1) how and why do stars form from giant gas clouds?; (2) how have stars enriched the universe in "heavy" elements?; and (3) what were galaxies like in the distant past when the first generations of stars formed?

We know that about 90 percent of the luminous material in our own Galaxy is in the form of stars that range from about 0.01 to 100 solar masses. We would like to understand why this is so; i.e., why do stars exist only in this approximate mass range and why is luminous matter mostly locked up in stars rather than spread throughout the interstellar medium (ISM) and in much more massive stars. While hydrogen and helium were created at the very beginning of the universe, we know that all the heavier elements have been synthesized in the cores of stars and during supernova explosions; in fact, only elements up through iron are made during normal stellar evolution, while the remaining ones are known to be created exclusively through explosive nucleosynthesis. So the star formation process is intimately connected with the evolution of the universe and to understand the latter, we must determine how the former process has changed as succeeding generations of stars formed from increasingly metal-rich material. Dr. Heap then divided her talk into two main topics: (1) what have HST observations told us to date about the star formation process; and (2) what have we learned

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about young galaxies that were formed in the distant past. Since the more massive (>10 solar masses) stars are the brightest and can be observed at great distances, and because they evolve much more rapidly than solar-like stars, they are the objects upon which the HST studies about star formation are based. Massive stars are also important because, unlike run-of-the-mill solar stars, which lock up almost all their material, the former disperse most of their material during their lives and make it available to succeeding generations.

We know that massive stars not only contribute significantly to the enrichment of the ISM at the ends of their lives, but they also pump their products outward on a continuous basis in the form of strong stellar winds as they evolve. Theoretical calculations show, in fact, that the final masses of all stars are not very much different, even though their initial masses may differ by four orders of magnitude or more. This is because massive stars lose about 90 percent of their original material during their evolutionary lifetimes, thus contributing almost all of the new matter for the formation of succeeding generations of stars. Calculations by, e.g., A. Maeder of Geneva Observatory, also show that the composition of contributed material changes as the stars become increasingly enriched with heavier elements. While present-day stars contribute helium, carbon, and oxygen, the latter two about equally, early stars that were much lower in metal abundance, contributed mostly helium and oxygen, but very little carbon.

Dr. Heap only briefly described the instruments aboard the HST, since, as she stated, they had been reviewed by Dr. Maran at our April meeting. She noted that the cameras (WF/PC II and the Faint Object Camera (FOC)) and spectrographs (the Goddard High Resolution Spectrograph (GHRS) and the FOS) are mainly sensitive in the blue and ultraviolet regions of the spectrum where the highest energy output from massive blue stars occurs.

We next saw a diagram of the stellar evolutionary cycle, beginning with the condensation of a large gas cloud into a cluster of stars containing objects of various masses, temperatures, and luminosities. As mentioned earlier, massive stars evolve faster and eject mass throughout their lives, eventually forming what is sometimes referred to as a superbubble that surrounds the cluster and is enriched in the heavier chemical elements synthesized by the stars. This material slowly mixes with the ambient ISM and eventually fragments, clumps, and condenses to form the next generation of stars. Although the mechanisms that provoke new star formation are not well understood at present, they probably consist of a mixture of shocks from supernova explosions and perturbing influences from galactic mergers, as we learned from Dr. Schweizer at our February 1994 lecture.

The distribution of masses in a cluster at the time of its formation is generally described by the Salpeter "Initial Mass Function" (IMF), which can be written as a power law; i.e., the number of stars of a given mass is proportional to the mass raised to some

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EXPLORING THE SKY

by John B. Lohman

National Capital Astronomers and the National Park Service offer Exploring the Sky, an astronomy observing program for the general public, every year from April through November. The program is held at the open field nearest the Rock Creek Park Nature Center. NCA members bring telescopes for the program.

The schedule for 1994 follows:

Saturday 11 June:	9:00 pm
Saturday 23 July:	9:00 pm
Saturday 13 August:	9:00 pm
Saturday 24 September:	8:30 pm
Saturday 08 October:	8:00 pm
Saturday 19 November:	7:30 pm

In case of cloudy weather, the observing program is replaced by a planetarium show at the Rock Creek Park Nature Center. In case of rain the program is cancelled. (The program continues as late into the night as seems appropriate.)

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power. The exponent derived from mass distributions in young clusters and from field stars in our Galaxy is generally in the range -1.3 to -1.5, the negative reflecting the fact that fewer stars of higher masses are formed. The lower- and upper-mass limits for cluster stars are very important quantities, but these are not well established at present, and they may be, as Dr. Heap subsequently explained, dependent in a complex way on initial conditions such as heavy-element abundances.

The most important question concerning the IMF is whether or not it has remained the same over the lifetime of the universe since star formation began, or, equivalently, is it the same in other galaxies as it is in the Milky Way? We also need to determine whether or not the IMF is universal because it might have been different not only in terms of composition, but because in earlier times when galaxies were closer together, collisions were more frequent and these violent events might have resulted in different distributions of masses. Since the latter question cannot be answered from first principles, we must rely on observations to give us clues about its answer.

Ground-based observations in our own Galaxy have indicated that stars of up to 60 solar masses can form in lower density clusters and up to 30 solar masses in starburst regions (areas of enhanced star formation). Observations of star forming regions in the closest external galaxy, the Large Magellanic Cloud (LMC), made with the HST, however, indicate that more massive stars have formed there. Since the LMC is of lower metal content than the Milky Way, this does indicate that perhaps varying IMFs of the past have allowed higher upper mass limits. The LMC area studied is known as 30 Doradus, an extermely large H II region composed of ionized gas and numerous star clusters. The densest area of 30 Doradus, known as R 136, has now been resolved into stars and it is possible to take spectra of individual cluster members in a dense subregion known as R 136a. Dr. Heap showed a color image of the R 136a region in which all but the very center of the cluster is resolved into a myriad of bright blue stars. Photometric observations calibrated for mass by theoretical models indicate that in the outer regions of R 136a, the proportion of high-mass stars is lower than it is in the higher density central region.

Although it was not possible to take spectra of very dense regions before the servicing mission, spectra of several stars in the less dense regions of both the LMC and SMC were taken with the GHRS by a group of German astronomers based in Munich. Comparisons with spectra of similar galactic stars show that there is more absorption in the latter, which is expected for stars of higher heavy-element abundances. Further analysis of absorption and emission features in these spectra yields strong indications that some LMC and SMC stars are considerably more massive than corresponding galactic stars of the same spectral types. More recent spectra taken with the GHRS and analyzed in collaboration with the Munich group show rather good agreement with theoretical models of stars up to 100 solar masses, except for a line of ionized helium. However, even more recent models by the Munich group showed better agreement if the mass were raised to 150 solar. Now new models generated within the last few weeks by a group at GSFC indicate that the higher mass may not be necessary to resolve the discrepancy,

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Volunteers With Telescopes Needed

On the evening of July 21 the Planetary Society is sponsoring a limited open house at the Naval Observatory for viewing Jupiter and possibly the effects of the impacts by Comet Shoemaker - Levy 9. NCA members with telescopes of at least 6 inch aperture are needed to participate. If you wish to volunteer, please call Bob Bolster, 703-960-9126.

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ATTENTION ALL NCA JUNIOR MEMBERS

Now that school is out, you will have more time to devote to your astronomy hobby. The NCA has a mentor program for junior members. Any Junior desiring help with an astronomy project may call me for referral to an adult member who has expertise in the Junior's particular interests. If you call me (at 301-564-6061), I'll be happy to try to find a mentor whom you may contact when you need assistance. Please don't be timid about calling. We are eager to help you. All Juniors, including youngsters in homes with NCA family memberships, qualify for this help.

Leith Holloway
Director of NCA Junior Division

so the question is still open and further work is needed.

Dr. Heap and her collaborators have now been able to obtain improved spectra of two stars near the center of R 136a using the GHRS through the improved HST optical system. These spectra appear to be uncontaminated by neighbors and show that one star is an O3 type and the other a Wolf-Rayet type. Further modeling by the GSFC group to match these spectra indicates that the extremely high masses are not needed, but the occurrence of early O- and WR-type stars together in the same young cluster presents another problem because the cluster is presumably coeval. The reason for this is that, according to stellar evolution theory, if a cluster is old enough to contain WR stars, then cluster stars a little less massive than the WR stars should be late O and early B, not early O stars. A possible explanation for this discrepancy is that the original models of Maeder need drastic revision; another group at the Max-Planck Institute in Garching, Germany has proposed that the outflow from these stars is due not only to radiation, but also to pulsational instability, thus altering the path of evolution dramatically. (These stars do seem to show the small variations in light that pulsational instabilities would produce.) The new HST observations are certainly producing high-quality data not heretofore available for improving the models of early-type, high-mass stars.

We then saw several images of young clusters in other galaxies taken by the WF/PC instrument. The young blue globular clusters in NGC 1275 and NGC 7252, which were discussed by Dr. Schweizer in our February 1994 lecture, are seen very clearly in the new images. As explained by Dr. Schweizer and elaborated on by Dr. Heap, the interaction of neutral hydrogen (H I) during a galactic merger produces heat and ionization, thus creating shock fronts that impinge upon molecular clouds and trigger bursts of star formation.

Additional images of "disturbed" galaxies that could never be adequately resolved with ground-based observations, show numerous individual young clusters when viewed with the HST cameras. Now that the optical system has been corrected, it should be possible to take spectra of many of these clusters to learn more about them. A color image of Messier 83 shows many young clusters that may be forming right now. An image in the light of H alpha clearly shows a superbubble of emission surrounding the clusters, as predicted by the star formation cycle discussed earlier.

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NCA Welcomes These New Members!

Brian G. Allen
4603 Highland Avenue
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Andrew I. Baines
2608 Ross Road
Chevy Chase, MD 20815

Lt. Col. Joe Bassi
8622 Vernon Avenue
Alexandria, VA 22309

Mark A. Chapman
15704 Mahogany Circle #102
Gaithersburg, MD 20878

Mary Pat Gaffney
6228 30th Street, NW
Washington, DC 20015-1514

Kwang-Suh Kim
2963 McKinley Street, NW
Washington, DC 20015

Earl L. Segal
10722 Goldwood Court
Potomac, MD 20854

James W. Taylor
127 North Colbert
Sherman, TX 75090

James A. Zwiebel
6317 Kenhowe Drive
Bethesda, MD 20817-5419

Shoemaker-Levy Impacts on Jupiter

by Robert N. Bolster

Following are the dates and times for impacts of the comet nuclei on Jupiter. The times are uncertain by 45 minutes. More accurate data should be available in June or July. Only the second July 16 event occurs during darkness with Jupiter at a favorable altitude in the Washington area. Data from IAU Circ. 5941.

July Date	Times (EDT)
16	15:25, 22:40
17	02:30, 10:30, 10:40, 20:30
18	03:10, 14:45
19	06:05, 17:20
20	05:50, 10:40, 15:10
21	02:45, 10:40, 14:00, 17:05
22	00:20, 03:40

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To learn more about the nature of star formation in the early universe, we must make observations of galaxies at much greater distances, and the HST holds some promise for doing this. However, the high resolution needed for such work means that we can only observe out to a distance far short of where we expect to see first generations of stars. As an alternative, we might try to find primitive galaxies that are relatively nearby but are just in the process of forming, as evidenced by their low metal content. The unusual galaxy I Zw 18 shows low abundances of heavier elements characteristic of a young galaxy, but enough are found to indicate that it is not primeval. However, the hydrogen cloud from which the galaxy apparently formed and in which it is still embedded, was thought to be possibly primeval, as was indicated by earlier spectra taken with the International Ultraviolet Explorer spacecraft. Higher resolution spectra recently obtained with the GHRS show that absorption lines of Si II and O I are present, so the hydrogen cloud is obviously not composed of primeval material, even though its heavy-element content is extremely low.

Dr. Heap then discussed a spectrum of a high-redshift quasar that displays seven individual spectra of intervening Lyman alpha clouds located at different redshifts. Abundance analyses of the individual spectra from these Lyman alpha systems show that the ratio of oxygen to carbon is three to six times that in the Sun, thus indicating that, as discussed earlier in connection with Maeder's models, this material was produced by early generations of massive stars.

Finally, Dr. Heap described some observations of a newly discovered gravitational lens found with the WF/PC. The galaxy being lensed by a closer cluster of galaxies should be very far away and presumably quite young, yet we can see that it is a starburst galaxy. Perhaps, then, it will be possible to observe star formation in the early universe. If spectra can be obtained of such lensed systems, it leaves open the possibility of determining abundances for much more distant objects that may give answers to some of our remaining questions about star formation in the distant past.

It is clear from Dr. Heap's interesting talk that the HST is aptly fulfilling its original goal of producing high-resolution observations of a quality unsurpassed by ground-based instruments. The vast amount of knowledge that will be gained in many areas of astronomy and astrophysics clearly demonstrates that the new concept of a serviceable space observatory whose facilities can be replaced and upgraded periodically is an appropriate way to go for future missions. Given the HST's expected lifetime of 15 years and the great quantity of valuable data that will be accumulated over that period, one would be hesitant to conclude that the expenditure has not been worthwhile.

The NCA wishes to express its gratitude to Dr. Heap for giving us this fascinating lecture on the scientific accomplishments of the HST. I also wish to thank Sally for reviewing a draft of this article and for making suggestions for its improvement.

National Capital Astronomers, Inc.

is a non-profit, public-service corporation for advancement of the astronomical sciences and is the astronomy affiliate of the Washington Academy of Sciences. For information, call NCA: (301) 320-3621.

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 the monthly newsletter of NCA, *Star Dust*, and an optional discount subscription to *Sky & Telescope* magazine.

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.

Astronomical Telescope & Binocular - Public Seminar, for Selection, Use, and Care, 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, products, and services, including *Sky & Telescope* magazine.

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

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Note: If you already subscribe to ***Sky & Telescope***, please attach a recent mailing label. You may renew this subscription through NCA for $22 when it expires.

Make check payable to National Capital Astronomers, Inc., and send with this form to:

Jeffrey Norman Apt. 717, 5410 Connecticut Avenue, NW, Washington, D.C. 20015.

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 Shakey's: Take Wisconsin Avenue north or south to East-West Highway (Route 410). This is one-half block south of the Bethesda Metro stop. Shakey's is on the south side of 410 just east of Wisconsin. Parking is available at no charge in lots directly across from the restaurant. Note that you don't have to eat pizza. Shakey's has a variety of other food, including sandwiches, salads, etc.

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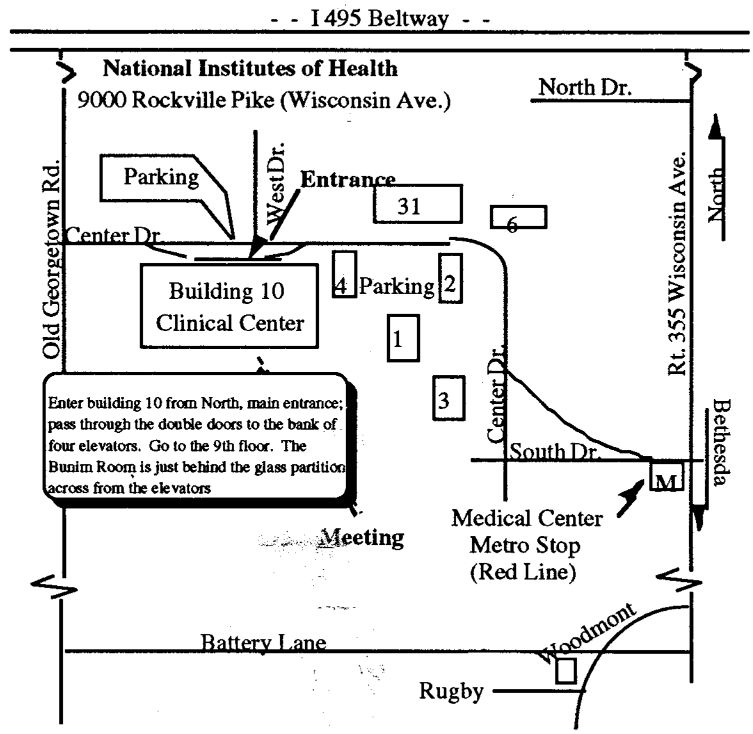

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