Star Dust

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November Speaker: Dr. Joan Centrella — "Binary Black Holes and Gravitational Waves"

Dr. Joan Centrella, NASA's Goddard Space Flight Center, will present the talk "Binary Black Holes and Gravitational Waves" at the November 10 meeting of the National Capital Astronomers, 7:30 P.M., at the University of Maryland Observatory in College Park Maryland.

Abstract
The final merger of two black holes releases a tremendous amount of energy, more than the combined light from all the stars in the visible universe. This energy is emitted in the form of gravitational waves, and observing these sources with gravitational wave detectors such as LIGO and LISA requires that we know the pattern or fingerprint of the radiation emitted. Since black hole mergers take place in regions of extreme gravitational fields, we need to solve Einstein's equations of general relativity on a computer in order to calculate these wave patterns.

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March 2007 Talk by Dr. Ben Sugerman — "How Supernovae Shed Light on Some 'Obscure' Questions"

Reviewed by Dr. John Albers and Dr. Tom Kitchens

This talk was presented to the NCA at the University of Maryland Observatory in College Park on March 10, 2007 by Dr. Ben Sugerman of Goucher College in Baltimore, Maryland.

The focal point of the talk was to show the various aspects of the use of the high-intensity, short-duration electromagnetic radiation pulses generated during supernovae and novae (as well as other possible pulse events – Cepheid variables, x-ray and gamma-ray pulses) in their various interactions with dust. The light from supernovae can be used as a probe to investigate the usually obscure or unseen dust. The dust being probed could come from a supernova or nova, could come from a previous stage of the star's evolution, or could come from interstellar space or intergalactic background space dust.

The talk was broken up into three general parts. The first focused on a brief introduction to stellar evolution as a background for supernova and nova generation. The second part developed the central idea of the light pulses and light echoes. The third part presented a detailed discussion of dust, its detection and quantification, with particular emphasis on the dust production in highly red-shifted and hence very early galaxies**,** where superno-

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Planning for Celebration of the 70th Anniversary Year of the NCA

Elizabeth Warner, Walt Faust, and Jack Gaffey

A celebration of NCA's 70th birthday having been suggested by several members, this aspiration was brought to the floor at the October 13 gathering. There was general approval then; and subsequent e-messages have been uniformly in favor. Though there is some divergence of preferences, a consensus is adequately defined for us to close upon some broad outlines.

We will gather at the Observatory on Saturday December 8, at 7:30 PM to eat!

Elizabeth Warner has volunteered to chair the 70th-Anniversary Celebration Committee. She will be the person to contact for all aspects of getting organized: warnerem @astro.umd.edu ; 703-587-0181 (c), 301-405-6555 (w). She has put together a webpage at http://www.astro.umd.edu/openhouse/programs/NCA70th.html which will summarize the current status of the planning.

An overall theme is suggested, such as "Seventy Years of Astronomy through the Eyes of the NCA"; this might project onto choices of decorations, etc.

Volunteers will be needed for a variety of supportive functions (logistics, food, entertainment). Please contact Elizabeth and let her know with what you can help. Jay Miller has initiated a ***sign-up list***; the use

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Calendar of Events

The Public is Welcome!

NCA Home Page: http://capitalastronomers.org

NCA Mirror- and Telescope-making Classes: Fridays, November 2, 9, 16, 23, and 30, 6:30 to 9:30 P.M. at the Chevy Chase Community Center, at the northeast corner of the intersection of McKinley Street and Connecticut Avenue, N.W. Contact instructor Guy Brandenburg at 202-635-1860 or email him at gfbrandenburg @yahoo.com.

Open house talks and observing at the University of Maryland Observatory in College Park on the 5th and 20th of every month at 8 P.M. (Nov.-Apr.) or 9 P.M. (May-Oct.). The talks are non-technical. There is telescope viewing afterward if the sky is clear.

Dinner with NCA members and speaker: Saturday, November 10 at 5:30 P.M., preceding the meeting, at the Garden Restaurant in the University of Maryland University College Inn and Conference Center. See map and directions on Page 8.

Upcoming NCA Meetings—Saturdays

November 10, Dr. Joan Centrella, Chief, Gravitational Astrophysics Laboratory, NASA/ Goddard Goddard Space Flight Center. Title of talk is "Binary Black Holes and Gravitational Waves

December 8, NCA 70th Anniversary Celebration

January 12, 2008, speaker is Dr. James Zimbleman, from the National Air and Space Museum, who will speak about "Mars' Geology"

February 9, 2008, Dr. Rhonda Stroud from the Naval Research Laboratory will speak about the Stardust Mission

March 8, 2008, tbd

April 12, 2008, tbd

May 10, 2008, tbd

June 14, 2008, speaker is Dr. Harold Williams from Montgomery College.

Please Get *Star Dust* Only Electronically

National Capital Astronomer members able to receive *Star Dust,* the newsletter of the NCA via e-mail as a PDF file attachment, instead of hardcopy via U.S. Mail, can save NCA a considerable amount of money on the printing and postage in the production of Star Dust (the NCA's single largest expense) and also save some trees. If you can switch from paper to PDF please contact Michael L. Brabanski, the NCA Secretary-Treasurer, at mlbrabanski@verizon.net or 301-649-4328 (home). Thank you.

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For more than 30 years, scientists have tried to compute these wave patterns. However, their computer codes have been plagued by problems that caused them to crash. This situation has changed dramatically in the past two years, with a series of amazing breakthroughs. This talk will take you on this quest for these gravitational wave patterns, showing how a spacetime is constructed on a computer to build a simulation laboratory for binary black hole mergers. We will focus on the recent advances that are revealing these waveforms, and the dramatic new potential for discoveries that arise when these sources will be observed by the space-based gravitational wave detector LISA.

Biography

Joan Centrella received her Ph.D. from Cambridge University, where she was a student at the Institute of Astronomy. Following postdoctoral appointments at the University of Texas and the University of Illinois, she joined the faculty of Drexel University in the Physics Department. In 2001, she moved to NASA's Goddard Space Flight Center to join their newly-formed gravitational wave astrophysics group, where she leads their source modeling and numerical relativity effort in support of LISA. In 2004, she became head of the Gravitational Astrophysics Laboratory, which encompasses the gravitational wave and theoretical astrophysics groups at Goddard. Her research interests include black hole mergers, gravitational waves, numerical relativity, structure formation and cosmology.

In May 2007, she was awarded the NASA Exceptional Scientific Achievement Medal for ground-breaking work in the simulation of gravitational wave signals from merging black holes.

The deadline for the December Star Dust is November 28. Please send your material to Elliott Fein by that date to ensure inclusion.

Send submissions to Elliott Fein at elliott.fein @verizon.net.

Articles submitted may be edited to fit the space available.

If a reviewer wants to have the speaker review the review then any corrections therefrom must be completed when the review is sent to me by the deadline. I need to have a final version by the stated deadline. Also, if a reviewer sends me a review before the deadline (which is great!) and says that it "final" then I will not accept changes to it after I receive it.

Planning for Celebration of the 70th Anniversary Year of the NCA

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of such a list should be coordinated with Elizabeth.

Members will share a potluck feast of items in pre-agreed categories; again the use of a ***sign-up list*** will be used. Since Jay Miller initiated the prior list, he is nominated to maintain this one as well. These will be served together with cake(s), and ice cream supplied by the management; and unspecified liquid refreshment from unspecified sources.

Distinguished scientist members, and lay members too, will recount critical historical developments over these 70 years, with just a single speaker at any given moment: *Speakers should emphasize the exhilarating aspects, rather than the technical details*

Members are encouraged to bring old photos, slides, videos, etc to the November meeting and give them to Elizabeth Warner or email them to ewarner@umd.edu for possible inclusion in a presentation during the celebration. Volunteers are needed to put together this presentation.

The proceedings themselves will be videoed and edited for posterity, through the combined efforts of Jay Miller, Michael Chesnes, and Elizabeth Wallace.

In the News

Reported by Dr. Nancy Grace Roman

The International Year of Astronomy 2009

The vision of the International Year of Astronomy (IYA2009) is to help the citizens of the world rediscover their place in the Universe through the day- and night-time sky, and thereby engage a personal sense of wonder and discovery. All humans should realize the impact of astronomy and basic sciences on our daily lives, and understand better how scientific knowledge can contribute to a more equitable and peaceful society.

The International Year of Astronomy (IYA2009) will be a global celebration of astronomy and its contributions to society and culture, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei. The aim of the Year is to stimulate worldwide interest, especially among young people, in astronomy and science under the central theme "The Universe, Yours to Discover." IYA2009 events and activities will promote a greater appreciation of the inspirational aspects of astronomy that embody an invaluable shared resource for all nations.

The IYA2009 activities will take place locally, regionally and nationally. National Nodes in each country have been formed to prepare activities for 2009. These Nodes establish collaborations between professional and amateur astronomers, science centers and science communicators in preparing activities for 2009. More than 90 countries are already involved, with well over 140 expected. To help coordinate this huge global program, and to provide an important resource for the participating countries, the IAU has established a central Secretariat and this website (http://www.astronomy2009.org/) as the principal IYA resource for public, professionals, and media alike. Source: *Wikipedia, The Free Encyclopedia*. <http://en.wikipedia.org/wiki/International_Year_of_Astronomy>.

NASA Maps the Moon with Google

From: NASA News, Sept. 18, 2007

New higher-resolution lunar imagery and maps that include NASA multimedia content now are available on the Google Moon Web site.

Updates include new content from the Apollo missions, including dozens of embedded panoramic images, links to audio clips and videos, and descriptions of the astronauts' activities during the missions. The new content is overlaid on updated, higher-resolution lunar maps. Also added are detailed charts of different regions of the moon suitable for use by anyone simulating a lunar mission.

"NASA's objective is for Google Moon to become a more accurate and useful lunar mapping platform that will be a foundation for future web-based moon applications, much like the many applications that have been built on top of Google Maps," said Chris C. Kemp, director of strategic business development at NASA's Ames Research Center, Moffett Field, Calif. "This will make it easier for scientists everywhere to make lunar data more available and accessible."

Google Moon's visible imagery and topography are aligned with the recently updated lunar coordinate system and can be used for scientifically accurate mission planning and data analysis. The new site is designed to be user-friendly and encourage the exchange of data and ideas among scientists and amateur astronomers.

This announcement closely follows the release of new NASA content in Google Earth, including photographs taken by NASA astronauts and imagery from NASA's Earth observing satellite sensors, such as the Sea-viewing Wide Field of View Sensor, Landsat and the Moderate Resolution Imaging Spectrometer.

Astronaut photography was developed in collaboration with the Crew Earth Observations team, part of the Image Science and Analysis Laboratory at NASA's Johnson Space Center, Houston. Satellite imagery of Earth was developed in partnership with the Earth Observatory team at NASA's Goddard Space Flight Center, Greenbelt, Md.

The alliance was accomplished under a Space Act Agreement signed in December 2006 by Google and NASA's Ames Research Center. Google is headquartered near Ames in northern California's Silicon Valley.

For more information on Google Moon, visit: http://moon.google.com.

For more information on Google Earth, visit: http://earth.google.com.

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vae were the only source of dust. Ordinary stars of less than $8M_O$ (where M_O is the solar mass) had not evolved sufficiently to produce dust.

Stellar Evolution (http://en.wikipedia.org/wiki/Stellar_evolution)
The life of a star is dominated by the fusion processes taking place in its central core. Roughly 90% of stellar life involves fusing hydrogen to helium. The heavier helium slowly collects in a central core. However, the temperature, T, and the density, ρ, are not high enough to begin fusing helium into heavier elements. Gradually, T and ρ increase to begin helium fusion into carbon and oxygen. Evolution of the star past this point depends critically upon its initial stellar mass.

$M_O < 8$
For a single star with initial mass below $8M_O$, the carbon and oxygen core does not have a high enough T and ρ to undergo further fusion into heavier elements. The carbon and oxygen core is surrounded by hydrogen and helium fusing shells, which are blown off as stellar wind or a planetary nebula. The hydrogen and helium shells are farther from the core and are weakly bound so that outward radiation pressure is able to push off several M_O from the shells. The final result is a slowly cooling white dwarf and a planetary nebula which is illuminated by the diminishing light from the white dwarf.

However, if the $<8M_O$ evolved white dwarf is in a binary system (about 60% of stars in the Milky Way are in binary systems), then the white dwarf may have one of two possible encore performances. If the binary system is of the semidetached type and the binary companion to the white dwarf extends beyond its Roche lobe, then matter from the companion can pass through the inner Lagrange point and spill over to the white dwarf. This can lead to an asymmetric planetary nebula with both stellar cores inside the enveloping gas cloud. (A simple planetary nebula would result from a single $<8M_O$ star evolving to a white dwarf with a spherical planetary nebula while an asymmetric planetary nebula would result from a binary system with a white dwarf below 1.4 M_O, the Chandrasekhar limit. (http://en.wikipedia.org/wiki/Chandrasekhar_limit) If the mass transfer is small enough, then hydrogen and helium from the binary companion can be fused around the white dwarf and cause non-destructive, and possibly repetitive, nova explosions (http://en.wikipedia.org/wiki/Nova).

This can provide the light pulse needed for the light echo. However, if the matter accreted from the binary companion causes the white dwarf to exceed the 1.4 M_O Chandrasekhar limit, then the carbon and oxygen core can fuse explosively in a thermonuclear runaway and give rise to a Type Ia supernova explosion (http://en.wikipedia.org/wiki/Supernova).

$M_O > 8$
The other path for stellar evolution takes place when the initial stellar mass is above 8 solar masses. In this case, the carbon and oxygen core with the hydrogen and helium outer shells can undergo further fusion processes to generate higher mass elements. Repeated fusion with product core production and higher mass element shells can take place, producing a higher mass product core that fuses at a higher temperature and density. The process repeats and repeats. These produce higher mass cores surrounded with “onion skin” layered outer product shells. The process proceeds through the intermediate nucleons including hydrogen, helium, carbon, oxygen, neon, silicon, and ends with iron. The fusion process stops when the star develops an iron core because iron is the most tightly bound nucleus. The iron core continues to grow and be compressed until it reaches 100 billion K. At this point, the iron photo-dissociates into electrons and protons which combine (by inverse beta decay) to generate neutrons in a precursor of a neutron star. The resulting core collapse causes an implosive shock wave that tears through the star causing a massive explosion (http://en.wikipedia.org/wiki/Supernova). This Type II supernova results in either a neutron star or black hole. The final product is supernova ejecta (expanding debris cloud) and remnants (what is left of the core – a neutron star or a black hole). In the process, a strong, short-duration electromagnetic pulse is created that provides the probe of previously unseen dust.

Light Pulses and Light Echoes (http://en.wikipedia.org/wiki/Light_echo)
(Note that the above web site contains a number of interesting and useful references. In particular, references 4 and 5 have links to downloadable PDF versions of papers by Ben Sugerman and collaborators on light echoes and circumstellar environments.)

One of the first observations of the light echoes resulting from light pulses generated by a nova was seen in Nova Persei 1901. Following the detection of the nova, a nebulous cloud was observed, which seemed to expand and evolve in structure. This resulted from the reflection of the light pulse off the surrounding interstellar dust and the expanding ejecta cloud from previous stellar evolution and the resulting planetary nebula.

Light from a nova or supernova can be seen on Earth by a direct line-of-sight observation. The light traveling in a spherical wave can be scattered or reflected off dust.

This scattered or reflected light travels a larger distance than the direct line of sight and hence arrives at the observer on Earth at a later time. The paths taken by the light echo define an elliptical surface that can be used to determine the exact position of the scattering or reflecting element. Clearly, the two things needed to use this technique are a light pulse source (nova or supernova) and dust (the scattering element).

From the point of view of an analytical technique, the ellipse is somewhat unwieldy. However, for large distances, especially for distances larger than 1000 light-years, things can be described approximately by a more easily handled parabola. Hence, the analysis of the light echo data is performed using a light echo parabola. The key point is that light echoes can provide detailed 3D information. However, it is important to keep in mind that the visualization of a light echo in space is not a trivial matter as echoes appear in a parabolic space. This is especially the case when the structure of the dust cloud is far from symmetrical. Even the simplest cases can provide a caveat to the cavalier interpretation of the light echo data. Indeed, the three interesting illustrative examples of the underlying structure of dust cloud and the resulting light echo were very informative. These included: the echo off a perpendicular plane of dust that resulted in a circular

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image; the echo off a spherical shell of dust which has a front circular image which enlarges and then shrinks on the back edge; and the complex echo off the dust cloud of a bipolar nebula that has multiple structures with interesting circular off-axis components.

Interpreting echoes requires lots of thought and work. It is very important to look at many temporal light echo images to piece together the underlying structure. Indeed, extracting the underlying structure from the light echoes is somewhat akin to the classical inverse problem. In summary, light echoes can illuminate and yield exact information and positions of otherwise invisible dust, but it is not always straightforward to extract this information. In addition to the location of dust, light echoes in spectroscopic mode can be used to determine the physical, chemical, and thermal properties of the dust.

Nature of Dust (http://en.wikipedia.org/wiki/Interstellar_dust)
In general, dust grains range in size from nanometers to millimeters, with most of them on the order of a micron. The dust grains can be smooth or fluffy, round or elongated, depending upon how they were formed. They are typically carbon- or silicon-based materials, which form at 1000-2000 K and then cool and coalesce. They may form in the atmospheres of stars, stellar winds, novae, supernovae, etc.

Dust can reflect, scatter, absorb and emit light. Dust reflects and absorbs UV and optical radiation – hence the strong optical extinction (reduced optical transmission) that can hide things behind dust clouds. This is the curse of the optical astronomer.

Optical and UV absorption by the dust causes it to heat up and act like a black body emitting in the IR. In addition, preferential absorption in the blue causes reddening of images by scattering and absorption. There is also an effect due to grain size, where small spherical grains have large scattering in the forward direction.

The density of dust along with dust grain size and distribution are important. In addition, compositional effects can be seen (dependence on the carbon and silicon constituents). It is then clear that light echoes are excellent probes of dust and not only provide information on location, but also on the structure and composition of the dust.

Recent Light Echoes
Nova V838 Monocerotis (V838 Mon) experienced an outburst in Jan 2002. Both ground-based telescopes and the Hubble Space Telescope (HST) provided detailed images of the evolution of the light echo. The web site (http://en.wikipedia.org/wiki/V838_Monocerotis) provides excellent pictures and links to other sites discussing this highly studied source of light echoes. The dynamic evolution of dust structure and the interaction of the stellar wind with the environment are clearly evident. It is estimated that it will take 30 – 40 years to see the back side of the dust structure. Dr. Sugarman showed us 3D images of the temporal evolution of dust in a Type Ia SN at a d=11.2 Mpc (via Cepheid variables).

SN 1987a a Type II in the Large Magellanic Cloud (LMC) with a 20 – 25 M_O progenitor was the basis of Dr. Sugarman's work for seven years. A detailed sequence of light echoes showed ejecta going through the rings, which were formed well before the SN and its ejecta. From the time sequence, it is possible to generate details of the circumstellar environment (a peanut-shaped structure). Also, the carbon and silicon composition and density have been elucidated. Three rings of the light echo are from an underlying hourglass structure. The question arises as to the circumstellar dust shells – in particular, what are they and how are they formed? They appear to arise from the pulsation of the star with hot and cold regions. Cool regions generate the dust that is carried out by the stellar wind thus forming the circumstellar shell.

Dust in the Early Universe
The picture of the expanding Universe gives rise to some fundamental questions. It is known from Hubble's pioneering work that the universe is expanding. The galaxies that are farther away from us are moving fastest and hence are highly redshifted. Observations of galaxies formed 700 million years to 1 billion years after the Big Bang show a frequency shift from the mm region to mid IR region. Lots of mid IR in these very early galaxies implies the presence of lots of dust. About 10^8 M_O of dust per galaxy is needed to explain the observed mid IR. But this dust cannot come from low mass stars as they are still on the main sequence. Higher mass main sequence stars have stellar winds and produce some dust, but are not very efficient in this production. Hence, the source of dust in the early Universe must be from higher mass stars that have progressed to the supernova phase. The observed dust must arise from ejecta of SN in the early universe.

Why the Interest in the Dust?
The interest in the dust in the early Universe focuses on the role that dust must have played in the structure and evolution of the Universe after the Big Bang. The very early Universe was homogeneous and isotropic. Small fluctuations formed and grew bigger and eventually gave rise to the present structure. The life cycle of galaxies and the life cycle of the stars from gas and dust to stars and back to interstellar medium and then to the next generation of stars, etc., involves the presence of dust as dust absorbs and redistributes radiation. It absorbs UV and emits IR and hence has an effect on thermal transport in galaxies. In addition, dust locks up elements and provides a source of these building blocks upon destruction and eventual incorporation into future generations of stars and planets. So, it is important to understand the generation of dust in the early Universe.

How to Find Dust
The formation of dust takes place upon cooling following SN bursts (below 1000 to 2000 K) and usually takes place in the 2- to 3-year interval following the SN. The sequence of supernova and dust formation then takes place over a very short time frame and provides a very short window of opportunity for observation.

(Those looking for SN and dust are keenly aware of the story of the small child who comes running down the stairs one morning and asks his/her mother – "Isn't it true that we come from dust and we go back to dust?" The mother responds, "Yes, that's true." The child then says, "Well, you had better get upstairs to my room really quickly as there is someone under my bed who is either coming or going!")

When dust is formed, there is increased optical absorption by the dust – hence there is a decrease in the light intensity. The forming dust, behaving like a black body, then re-emits this absorbed energy in the mid IR. Hence, there is an unexpected in-

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crease in the mid IR emission. The optical loss followed by the mid IR emission is then the telltale sign of dust formation.

The SN ejecta and the forming dust are expected to grow and expand as an approximately spherical shell. The front edge is moving towards the observer and is blue shifted with normal intensity. The back edge is moving away from the observer and is red shifted, but has lower intensity as the light needs to go through more dust (back side and front side).

The light echo is used in a spectroscopic mode to compare intensity and frequency shifting to see the contributions of the parts of the forming dust which are moving toward and away from the observer. Clearly, emission line asymmetry contains information about dust formation.

Spectroscopic data from the SN 1987A light echo showed dust. The models used indicate that only about 10^{-4} M_O of dust was generated in the supernova. However, a supernova generates about $1M_O$ of ejecta. Hence the apparent dust production appears to be about 10^{-4} and this is really small! So, the real paradox is that if SN production of dust is so apparently small then what accounts for the observed dust in the early galaxies and Universe. SN do not appear to be THE answer but appear to be the ONLY answer. How can this be reconciled? Better quantitative data and more sophisticated models are needed.

Spitzer to the Rescue
The Spitzer Space Telescope has especially increased resolution and a special detection capability of mid IR from space. This is important as not all IR makes it through the atmosphere for ground-based detection. Earlier studies of SN2002hh in NGC6946 were of limited help in the problem. However, things changed when SN2003gd in M74 was investigated. This is a Type II P SN with an 8-12 M_O progenitor at 9.3 Mpc. Composite data for SN2003gd consisted of four data points in IR on the blue side and one data point on the red side. These results were from different instruments and at somewhat different times (one works with what one has). The data can be fitted to a 500K black body and suggests SN ejecta of about the right size (given the conditions of different instruments and different times). Further, the SN was optically confirmed by HST. In addition, light echo data were analyzed to provide some information about the dust. Time data show evolution with dust formation with the telltale signs of: an unexpected increase in optical extinction; mid IR excess changes with time as expected; and asymmetric emission lines. Hydrogen emission line profile data show temporal erosion on the red side, which is typical of dust generation.

Models for Determination of Dust Production
The observed light echoes and the spectroscopic data do not give quantitative dust information directly. This gets back to the classical inverse problem of uniquely linking the observed data to the characteristics of the source of the data. In carrying out this program, analysis of the data needs to be based upon certain models. In general, the models that have been used to determine the amount of dust production begin with the most simple. It is necessary to look at the most simple model to see what its predictions are and gauge the need for more complicated, i.e., more physically reasonable models.

The simplest model assumes that there is a uniform distribution of ejecta and that every dust grain is spherical and of the same size and temperature. Using this model for the data leads to the conclusion that there is 10^{-5} M_O dust production. This is too low and indicates that the model needs to be more physically based and hence needs more sophistication.

The first set of model changes has to do with the assumption that the grains are the same size, shape and composition. Unfortunately, this leads to no real change from the above conclusion.

The next change in the model has to do with the inclusion of shadowing of the dust grains by each other. This leads to a dust production of 10^{-4} M_O, which is an improvement but is not quite there yet.

Further changes in the model address the questions that maybe not all grains are at the same temperature and grains may not be uniformly distributed in the ejecta.

Models for SN explosions have density variations that lead to the result that the ejecta and eventually the dust will be lumpy and not smooth. Hence, it is appropriate to study the effects of lumpiness. Lumpiness changes absorption and emission (but with the same T assumption). The result of this model modification leads to the dust production of about 0.001 M_O, which is along the lines of a further improvement in the model and the accompanying improvement in the dust production results.

Further improvements in the models involve the need to look more realistically at the absorption and emission, especially with regard to temperature effects. To carry this out, use of a computer-based radiation transfer model is required. The overall result of these increasingly sophisticated model modifications leads to a 10^{-2} M_O dust production.

So, it appears that as the model is more physically reasonable and sophisticated, that dust production estimates from SN are increasing and producing a better picture of SN dust production.

Then the telltale signs of an unexpected increase in optical extinction, time-variable mid IR excess, and asymmetric emission lines, coupled with more complete and physically reasonable (but computationally more difficult) models give dust production of up to 0.02 $M_{O.}$ SN appear to be productive enough to explain the observed dust in both the early and present Universe. This ensures the evolution of the Universe, galaxies, stars, planets, elements, carbon-based life and us. So, check under your bed!

Additional References
Listed below are two references that, along with the web links and the noted downloadable references there, provide a fairly comprehensive picture of the supernova/nova light pulse and the use of light echoes in the identification and quantification of usually obscure dust.

The Supernova Origin of Interstellar Dust by Eli Dwek, *Science*, 14 July 2006, Vol. 313, pp. 178-180

Massive-Star Supernovae as Major Dust Factories by Ben E. K. Sugerman, et al., *Science*, 14 July 2006, Vol. 313, pp. 196-200

Mid-Atlantic Occultations and Expeditions to Early November

by Dr. David Dunham

Asteroidal Occultations

2007 Date	Day	EST	Star	Mag	Asteroid	dmag	dur. s	Ap. in.	Location
Nov 11	Sun	3:05	TYC07691093	11.5	Bilkis	2.9	8	7	OH,WV,w&seVA
Nov 16	Fri	1:31	PPM 92603	10.2	Metcalfia	3.4	6	5	nOH,nwPA,NY
Nov 18	Sun	1:44	SAO 39874	9.3	Wombat	6.1	1	3	NJ,PA,swNY
Nov 18	Sun	2:57	1 Arietis	5.8	2000 AD142	11.4	1	1	VA,sWV
Nov 19	Mon	5:08	TYC07481711	9.8	Nealley	5.2	12	4	NJ,sePA,MD,nVA
Nov 23	Fri	2:18	2UC37297689	11.9	Ausonia	0.5	18	8	NJ,nMD,sPA,nWV
Nov 27	Tue	5:58	2UC39628815	10.9	Lameia	3.2	4	6	VA,sWV,sOhio
Dec 5	Wed	17:50	2UC42014653	11.9	Dembowska	0.1	12	8	sNJ,DE,sMD,VA
Dec 20	Thu	0:09	TYC24160772	9.4	Lamberta	3.3	9	2	s.VA,sWV,KY

Lunar Grazing Occultations

DATE	Day	EST	Star	Mag	%	alt	CA	Location
Nov 15	Thu	17:31	SAO 188946	8.8	29+	26	17S	LaPlata,MD, Sun -8d; Media,PA
Nov 16	Fri	17:35	SAO 189931	8.6	39+	30	16S	Hancock,MD,Sun-8;Lewisburg,PA
Nov 27	Tue	5:03	40 Gem	6.4	89-	59	18S	Atlee, Yorktown, &Langley, VA
Nov 29	Thu	6:26	FZ Cancri	6.3	72-	60	18S	Richmond, VA; N. Canton, OH
Dec 7	Fri	6:03	SAO 183171	7.2	5-	6	24S	New Brunswick, NJ; Sun -11d

Total Lunar Occultations

DATE	Day	EST	Ph	Star	Mag	%	alt	CA	Sp.	Notes
Nov 13	Tue	18:38	D	ZC 2660	6.2	14+	6	56S	A3	Azimuth 226 degrees
Nov 15	Thu	17:35	D	SAO 188948	7.5	30+	26	41N	F7	Sun alt. -8 degrees
Nov 15	Thu	20:33	D	SAO 189031	7.9	31+	8	26N	G8	Azimuth 232 degrees
Nov 16	Fri	18:51	D	SAO 164087	7.0	40+	29	63N	K1	
Nov 17	Sat	18:41	D	ZC 3207	8.2	50+	37	82N	F	mag2 11 sep.1.3",PA 31d
Nov 17	Sat	22:17	D	SAO 164780	7.5	51+	14	82N	K0	Azimuth 240 degrees
Nov 18	Sun	18:30	D	ZC 3333	6.8	61+	42	88S	A5	mag2 8 sep 2.7",PA 127d
Nov 18	Sun	20:28	D	SAO 146287	8.0	62+	39	25N	A5	
Nov 19	Mon	19:54	D	14 Piscium	5.9	72+	50	39N	A2	ZC3474; 1983NemausaOccn
Nov 21	Wed	21:18	D	ZC 197	7.0	90+	64	31N	K0	may be close double
Nov 24	Sat	18:25	R	chi Tauri	5.4	100-	17	49S	B9	ZC647;term.dist4",WA194
Nov 25	Sun	2:21	R	ZC 701	6.6	99-	64	53N	F2	term.dist.10", WA 282d
Nov 25	Sun	20:54	R	ZC 840	6.3	96-	33	46N	K0	spec. binary; WA 304 dg
Nov 26	Mon	3:37	R	SAO 77604	7.0	95-	63	74S	K0	Milky Way field;WA 246d
Nov 26	Mon	4:06	R	SAO 77619	7.1	95-	57	71S	F2	Watts Angle 243 deg.
Nov 26	Mon	5:22	R	136 Tauri	4.6	95-	43	64N	A0	ZC890;close dbl?;WA 288
Nov 26	Mon	6:04	R	SAO 77724	7.0	95-	35	14N	B1	TermDist6";WA339;Sun-11
Nov 27	Tue	5:07	R	39 Gem	6.2	89-	57	76S	F8	ZC1061;WA253;close dbl?
Nov 27	Tue	5:16	R	40 Gem	6.4	89-	55	40S	B8	ZC1062; WA217; VA graze
Nov 27	Tue	22:47	R	T Gem	8-15	82-	29	67S	S	Mira variable
Nov 28	Wed	2:17	R	ZC 1195	6.8	81-	67	63N	B8	
Nov 28	Wed	4:38	R	ZC 1200	6.9	81-	70	82N	K0	
Nov 29	Thu	6:09	R	ZC 1340	6.6	71-	61	54S	A0	OH,WV,NC graze; Sun -11
Nov 29	Thu	6:40	R	FZ Cancri	6.3	71-	56	40S	M4	ZC1343; VAgraze; Sun -5
Nov 30	Fri	1:51	R	psi Leonis	5.4	62-	39	50S	M2	ZC 1434
Nov 30	Fri	4:55	R	SAO 98773	7.5	61-	64	68S	K0	
Nov 30	Fri	7:17	R	23 Leonis	6.5	60-	54	77N	M0	ZC 1449; Sun alt. +1deg
Dec 3	Mon	4:30	R	SAO 138553	7.5	32-	32	70N	K2	
Dec 4	Tue	3:14	R	SAO 138948	7.6	23-	8	31N	K0	mag2 11 sep. 7", PA 98d
Dec 4	Tue	5:18	R	ZC 1835	7.6	23-	28	87S	K2	
Dec 4	Tue	6:03	R	SAO 138978	7.6	23-	34	18N	K2	

More information is at http://iota.jhuapl.edu/exped.htm.

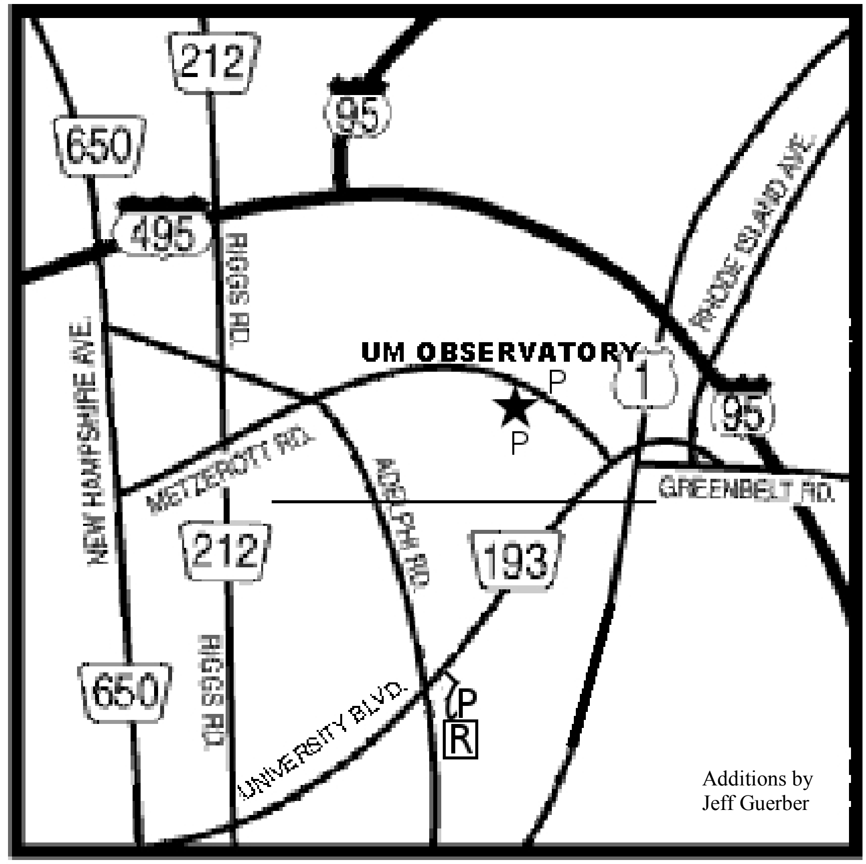
David Dunham, dunham@starpower.net, phone 301-474-4722

Getting to the NCA Monthly Meeting and the Dinner Before the Meeting

The NCA Meeting
NCA meetings are now held at 7:30 p.m. at the University of Maryland Observatory, in College Park. The observatory is located on Metzerott Road between Adelphi Road and University Blvd. in College Park. From the beltway (I-495):

- if on the Inner Loop, take Exit 28B toward Takoma Park, which puts you on New Hampshire Ave. (MD-650) south, turn left at the second light onto Adelphi Road, two more lights, turn left onto Metzerott Road, and proceed 0.6 miles to the observatory entrance (on your right);

- if on the Outer Loop, take the College Park/Route 1 exit. Head south on Route 1 for about a mile until you see a sign for 193 West. Get on 193 West. The first traffic light is at Metzerott Road. Take a right onto Metzerott Road. Once on Metzerott Rd., continue past a traffic light at St. Andrews Place. The observatory entrance is about a quarter of a mile on the left side of the road after that. The observatory entrance is slightly hidden, so slow down to turn left as soon as you pass a large "System Administration" sign. The observatory entrance is almost directly across the street from the UM System Administration sign (3300 Metzerott Rd.).



Getting to the NCA Meeting
Star=Observatory R=Restaurant P=Parking

Do You Need a Ride?

Please contact Jay Miller, 240-401-8693, if you need a ride from the metro to dinner or to the meeting at the observatory. (Please try to let him know in advance by e-mail at rigel1@starpower.net.)

Observing after the Meeting

Elizabeth Warner

Following the meeting, members and guests are welcome to tour through the Observatory. Weather permitting, several of the telescopes will also be set up for viewing.

The Dinner before the Meeting
At 5:30 p.m., before the meeting, please join us for dinner at the Garden Restaurant in the UMD University College Inn and Conference Center, 3501 University Blvd. East at Adelphi Rd. From the Beltway, either take New Hampshire Ave. south, turn left at the second traffic light onto Adelphi Rd., and at the third light (passing Metzerott) turn left onto University then immediately right into the garage; or, take US-1 south, turn right onto University Blvd. west, and take it to the intersection with Adelphi Road. Park either in the garage (costs), or in Lot 1 nearby (free). To get to the observatory, exit to the right onto University Blvd. (MD-193) east, and at the second light turn left onto Metzerott Road. Once on Metzerott Rd., continue past a traffic light at St. Andrews Place. The observatory entrance is about a quarter of a mile on the left side of the road after that. The observatory entrance is slightly hidden, so slow down to turn left as soon as you pass a large "System Administration" sign. The observatory entrance is almost directly across the street from the UM System Administration Sign (3300 Metzerott Rd.).

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Editor: Elliott Fein; Co-editor: Adele Fein; Editorial Advisors: Walt Faust, John D. Gaffey, Jr, Jeffrey Norman, Wayne Warren, Harold Williams; PDF distributor: Jay Miller

National Capital Astronomers, Inc.

http://capitalastronomers.org

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NCA is a nonprofit, membership-supported, volunteer-run, public-service corporation dedicated to advancing astronomy, space technology, and related sciences through information, participation, and inspiration, via research, lectures, presentations, publications, expeditions, tours, public interpretation, and education. NCA is the astronomy affiliate of the Washington Academy of Sciences. NCA is an IRS Section 501(c)(3) tax-deductible organization. All are welcome to join NCA.

SERVICES & ACTIVITIES:

Monthly Meetings feature presentations of current work by researchers at the horizons of their fields. All are welcome; there is no charge.

NCA Volunteers serve in a number of capacities. Many members serve as teachers, clinicians, and science fair judges. Some members observe total or graze occultations of stars occulted by the Moon or asteroids.

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

Consumer Clinics: Some members serve as clinicians and provide advice for the selection, use, and care of binoculars and telescopes and their accessories. One such clinic is the semi-annual event held at the Smithsonian Institution National Air and Space Museum.

Fighting Light Pollution: NCA is concerned about light pollution and is interested in the technology for reducing or eliminating it. To that purpose, NCA is an Organization Member of the International Dark Sky Association (IDA).

Classes: Some NCA members are available for educational programs for schools and other organizations. The instruction settings include star parties, classroom instruction, and school-teacher training programs that provide techniques for teaching astronomy. NCA sponsors a telescope-making class, which is described in the *Star Dust* "Calendar of Monthly Events."

Tours: On several occasions, NCA has sponsored tours of astronomical interest, mainly to observatories (such as the National Radio Astronomy Observatory) and to the solar eclipses of 1998 and 1999.

Discounts are available to members on many publications, products, and services, including *Sky & Telescope* magazine.

Public Sky Viewing Programs are offered jointly with the National Park Service, and others. Contact: Joe Morris, joemorris@erols.com or (703) 620-0996.

Members-Only Viewing Programs periodically, at a dark-sky site.

NCA Juniors Program fosters children's and young adults' interest in astronomy, space technology, and related sciences through discounted memberships, mentoring from dedicated members, and NCA's annual Science Fair Awards.

✂

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FIRST CLASS
DATED MATERIAL

NCA Will Meet on November 10!

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