Star Dust

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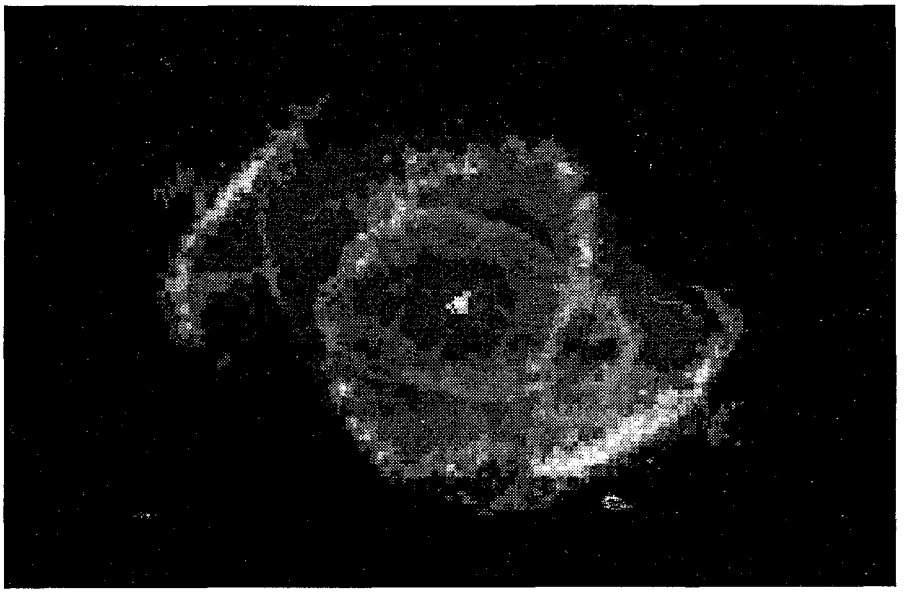
Cosmic Rays and Super Nova Remnants

by Andrew W. Seacord, II

The 1996 December meeting of the National Capital Astronomers will be held Saturday December 7 at 7:30 at the Lipsett Amphitheater in the Clinical Center (Building 10) of the National Institutes of Health (NIH). Our speaker will be Robert Petre of the Goddard Space Flight Center Laboratory for High Energy Astrophysics. His research areas involve x-ray astronomy and cosmic rays in super nova remnants.

Super nova remnants (SNRs) are one of the products from the cataclysmic deaths of stars having a main sequence mass greater than about 8 solar masses. Observations of SNRs throughout the electromagnetic spectrum show the spectra of synchrotron radiation which is produced by the encounter of electrons, traveling near the speed of light, with a magnetic field. From this we infer that SNRs contain high particle energies and a magnetic field which, in places, is substantially greater than the average magnetic field of the galaxy which is in the order of a few microgauss. (The magnetic field of the earth near the surface is about 0.5 gauss.) Another indication of high energies in SNRs is the fact that our favorite SNR, the Crab Nebula, is a strong x-ray source. These high energies have been sustained for so long by the pulsar at the center of the Crab.

Cosmic rays are high energy particles — not electromagnetic radiation — which have two components. One component is a stream of protons produced by solar activity, mainly solar flares. The other component of cosmic rays comes to us from all directions. They are distributed evenly around the celestial sphere and consist mainly of protons but also nuclei of heavy elements from helium to those with an atomic number greater than 10. The source of these cosmic rays is not certain. However, it is known that the product of stellar death is the nucleosynthesis of heavy elements. It is not unreasonable to suspect that the large magnetic fields present at the time of the supernova explosion are very capable of accelerating the heavy element nuclei, ejected by the explosion, to high energies and, thereby, creating the non-solar cosmic rays. The presence of the Milky Way's magnetic field will scatter these particles so that we observe them to come from all directions around the celestial sphere. There is more to say, but that is the subject of Dr. Petre's talk for the NCA December meeting. ○



Super Nova Remnant NGC 6543a, Hubble Space Telescope • Wide Field Planetary Camera 2 (WFPC2), January 1995

Calendar of Monthly Events

The Public is Welcome!

NCA Home Page: http://myhouse.com/NCA/home.htm

Mondays, December 2, 9, 16, 23 and 30, 7:30 PM-Public nights at U.S. Naval Observatory (USNO), in Northwest Washington, D.C. (off Massachusetts Avenue). Includes orientation on USNO's mission, viewing of operating atomic clocks, and glimpses through the finest optical telescopes in the Washington-Baltimore region. Held regardless of cloud cover. Information: USNO Public Affairs Office, 202/762-1438. Home page: http://www.usno.navy.mil.

Tuesdays, December 3, 10, and 17, 7:30 PM-Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 202/362-8872.

Fridays, December 6, 13, and 20, 7:30 PM-Telescope making classes at American University, McKinley Hall Basement. Information: Jerry Schnall, 202/362-8872.

Fridays, December 6, 13, 20, and 27, 8:30 PM-Open nights with NCA's Celestron–14 telescope at Ridgeview Observatory; near Alexandria, Virginia; 6007 Ridgeview Drive (off Franconia Road between Telegraph Road and Rose Hill Drive). Information: Bob Bolster, 703/960-9126.

Saturday, December 7, 5:30 PM-Dinner with the speaker and other NCA members at North China Restaurant at 7814 Old Georgetown Road (near Cordell), Bethesda, MD. *See* map and description on back page.

Saturday, December 7, 7:30 PM-NCA meeting, will feature Robert Petre (Goddard Space Flight Center Laboratory). His talk will be "Cosmic Rays and Super Nova Remnants." More information on Comet Hale-Bopp will also be provided. For directions, *see* map and description on back page.

Wednesday, December 11, Noon to 1:00 PM-Lecture: Tom Crouch, Curator, and Dominick A. Pisano, Curator, Aeronautics Department, National Air and Space Museum (NASM), "A Poised for Take-Off: The Roots of the National Air and Space Museum, 1876-1976," in celebration of the 50th anniversary of NASM and the 20th anniversary of the NASM building. Located in the Mayer Auditorium of the Freer Gallery of Art; free to the public. For more events and details *see* page 8.

Wednesday, December 11, 11:00 AM-Lecture: Bruce Campbell, NASM, "The Mountaintops of Venus," Department of Terrestrial Magnetism, Carnegie Institute of Washington, 5241 Broad Branch Road, NW, Washington, DC. Information of weekly events: (202) 686-4370 (exts. 4378 or 4383).

Sunday, December 15, 7:00 PM-Wintertime Stars, Historic Bladensburg Waterfront Visitor Center, 4601 Annapolis Rd., Bladensburg, MD. Details & Directions: Geoffery C. Lane (NCA), 301/927-2163, or 301/927-8166 (fax).

Saturday, December 21, 7:00 PM-"The Day of the Sun's Return, the Winter Solstice." Montogomery College's Planetarium, Takoma Park, MD. Information: 301/650-1463.

NCA and National Park Service (NPS) ***Exploring the Sky*** program will be continued in the spring. Details & Directions: Nature Center, 202/426-6829; Joe Morris (NCA), 703/620-0996. Nature Center Home page: http://www.nps.gov/rocr/.

See page 8 for more Washington area astronomical events. Other events too numerous to list in *Star Dust* are listed in the publications *Sky & Telescope*, the *Astronomical Calendar 1996*, the *Observer's Handbook 1996*, in numerous software packages, and other links available on the NCA Home Page (*see* above for address). NCA members can purchase all these (and much more) at a discount. To join NCA, use membership application on page 9.

During questionable weather, call the IOTA Hotline (Phone: 301/474-4945) for NCA meeting status. The absence of a cancellation notice on the Hotline means the meeting will take place.

Radio Galaxies Summary and Review

by Gary L. Joaquin

At our November meeting, Dr. John Graham gave a presentation on radio galaxies. He was quick to state that he was an astronomer, but not a specialist in radio galaxies, although it has been a topic of great personal interest to him for many years. The presentation that followed was informative, engaging, and even entertaining. The question and answer session that ensued immediately afterward was one of the most animated that I have seen in my four years as an NCA member. In writing this review, I am hopeful to not only capture the content of his lecture, but to relate some of the enthusiasm and wonder that was felt at this meeting.

One hundred years ago we were knowledgeable about the solar system. We knew about stars. We didn't know very much about galaxies. We weren't certain if galaxies were within our own Milky Way galaxy or separate star systems in their own right. More recently we have discovered objects like pulsars, quasars, and black holes. The universe is indeed more complicated that we had ever imagined.

Up until 50 years ago our knowledge was obtained exclusively from observations made in visual wavelengths visible to our own eyes. In the last 50 years we've been able to view the universe in a much wider range of wavelengths from a variety of new vantage points. Short wave lengths like gamma rays and x-rays are blocked by our atmosphere, requiring observation from space. Infrared observations can be made at high altitudes above the water vapor interference of our atmosphere. Longer wave lengths like radio waves penetrate our atmosphere enough to be observed from the ground.

The National Radio Astronomy Observatory has published pictures of the sky as it would appear at a wavelength of 6 centimeters. At first glance these images look like the same stars that we see in the visual wavelengths,yet stars are comparatively weak as radio wave radiators. They are also relatively close, averaging in distance of about 100 light years. In reality, the points of light that appear in the radio sky are radio galaxies that are typically 400 to 500 million light years away; very unusual objects to be so distant and so luminescent. By changing the wavelength in which you are viewing another universe appears to pop out.

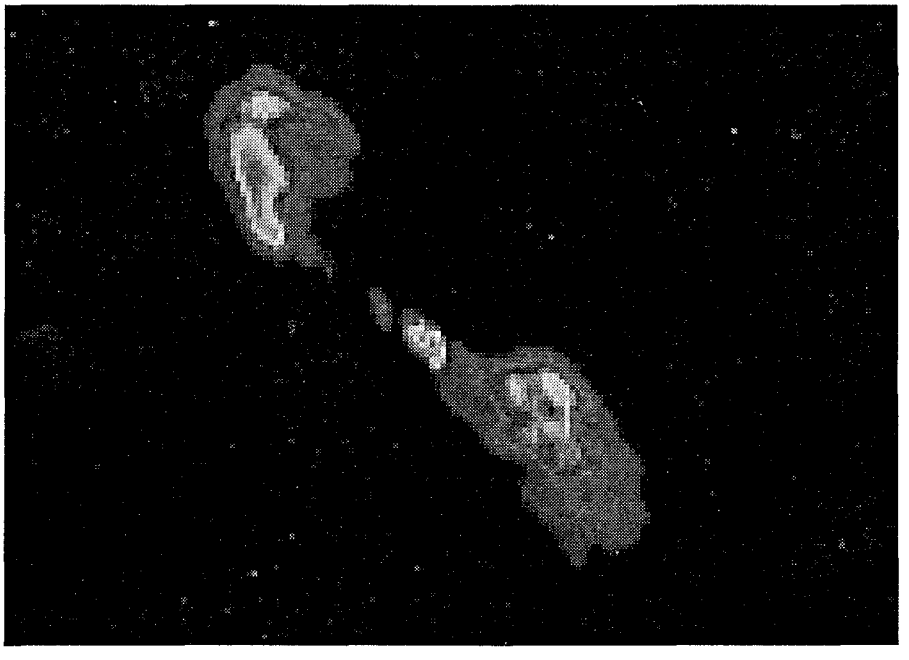


Figure 1) Centaurus A (also known as NGC 5128), a nearby galaxy in the southern sky, exhibits huge radio lobes stretching several degrees across the sky.

When radio astronomy began in the 1940s the first discrete radio sources to be discovered were radio galaxies with names like Virgo A and Centaurus A where "A" denotes the brightest radio sources in a given constellation. These radio galaxies often turned out to be unusually bright objects in the visual spectrum and received our attention first. While it is true that all galaxies radiate radio waves, not all galaxies radiate strongly. Our Milky Way is a typically weak source of radio waves radiating at a rate of about 10^{37} ergs/sec. (Our Sun radiates in the optical range at about 10^{33} ergs/sec) Typical radio galaxies are much stronger, ranging from 1 million to 100 million times more radiant.

Centaurus A (*see* figures 1 and 2) is the nearest of the radio galaxies and has long been recognized as a truly unusual object. When it was first discovered by radio astronomers in Sydney, Australia one of the biggest surprises was how large it was; the radio source itself extends about 5 or 6 degrees across the sky, about a tenth of a radian. We have since determined that this galaxy is about 10 million light years away, making this radio source about 1 million light years across, 10 times wider than our own Milky Way galaxy. These objects are probably the largest integral objects that we know about, only surpassed by clusters of galaxies and other fine structures in the universe. Some of the more distant radio galaxies are known to be up to 5 to 10 million light years across. Closer examination of this galaxy revealed a structure consisting of large radio lobes jetting out from a very compact nucleus.

Radio galaxies like Centaurus A were discovered at a time when the first atomic particle accelerators were being constructed in the 1940s and 1950s. During this time it was determined that the radio emission from these galaxies were very similar to that produced by synchrotron accelerators. One sees in a radio galaxy very similar radiation with electrons moving close to the speed of light. The total amount of energy stored

See GALAXIES, continued on page 4

GALAXIES, continued from page 3

in these objects is on the order of 10^{57} to 10^{61} ergs. Energies of this magnitude cannot be sustained for long unless replenished constantly. Radio galaxies immediately raise the questions: How are they continually powered? Will they last forever? How can we use them to probe the depths of the universe as far out as we can detect such galaxies?

Lets look at another example. The radio galaxy Cygnus A was mapped with the Very Large Array in New Mexico. This galaxy is much more distant that Centaurus A, about 600 million light years away. Like Centaurus A, Cygnus A was detected during the infancy of radio astronomy. Optically, if you look in the direction of Cygnus A all you see is a dim 17th magnitude galaxy in the center. Through a very large telescope it looks very much like Centaurus A, an elliptical galaxy with a gas lane across it. Its radio lobes are somewhat smaller than Centaurus A's, extending out approximately half a million light years. Very narrow jets can be seen coming from the galaxy's center.

The structures that we have examined in both of these examples require remarkable dynamics to sustain them. Collimated jets originating from a central source, create large lobes visible in the radio wave lengths on either side of the galaxy. These lobes do not rotate; it would require impossibly large amounts of angular momentum to turn them. They are essentially two big balloons blowing out on either side of the galaxy. Measuring the speed of these jets so far has been impossible without observation of spectral lines. However, we can estimate how fast this material is moving. In order to get out this far, on the order of hundreds to several millions of light years, the limiting factors becomes the age of the Universe and the speed of light. Given a Universe that is 10 to 20 billion years old, there is not enough time for this material to move these great distances at velocities between 10 and 100 km/sec (1 km/sec ≈ 1.6 miles/sec). We think that this material is moving somewhere between 1000 and 10,000 km/sec. However, the higher the velocity, the more difficult it becomes to describe this mechanism. We believe that there almost certainly needs to be something like a black hole

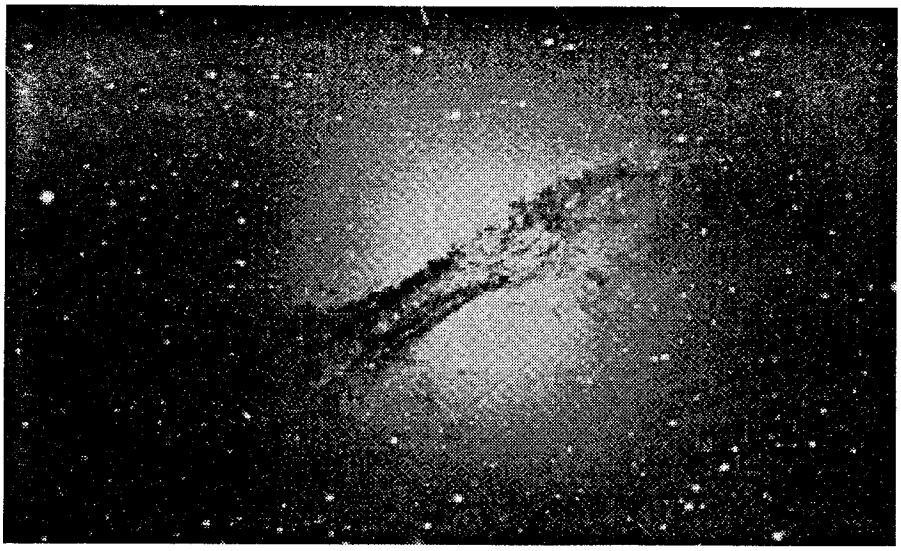


Figure 2) Centaurus A (also known as NGC 5128)

in the center of this structure. One of the great things that has occurred recently is that we have come to believe that black holes really do exist. The dust lanes around galaxies like Centaurus A so far preclude any measurements to prove this. Virgo A (Messier 87) is a better example. Astronomers using the Hubble Space Telescope have measured spectra of gasses moving so rapidly about the core of that galaxy that it is almost certain to contain a black hole.

We believe that almost all of the radio galaxies have a black hole with a mass of 100 million times greater than that of our sun existing in a volume roughly equal to our solar system. These objects are often called "super black holes" because they are so much larger than the black holes postulated to be at the center of x-ray sources. These "super black holes" have very peculiar properties. Because they are so large, they are not very dense. The average density of these black holes is not thought to be more than 1 gram/cm^3, the density of water. While this is not very dense when compared to ordinary matter, compared to interstellar space it is very dense indeed. When anything falls into these objects, they can't get out. They are true black holes.

Now that we understand some of the components lets examine how they interact in a model. Figure 3 shows the typical structure of a radio galaxy. Here you can see the a nucleus, probably a black hole, in the center of an accretion disk of dust and gas, that are all spinning very rapidly. As this material is pulled towards the black hole, its angular momentum is conserved, and it begins to revolve about the black hole faster and faster. Some of the material passes through the event horizon and into the black hole. The rest of the material continues to revolve faster and faster around the black hole. Some of the atoms lose electrons and become ionized, thus generating magnetic fields. Density and pressure build up forming a funnel shaped cavity around the black hole. To relieve this pressure high velocity jets form in the paths of least resistance perpendicular to the rapidly rotating disk, moving at velocities between 1000 to 10,000 km/sec. The dense dust and matter helps to focus the beams. As we described earlier, the particles have a synchrotron radiation signature. These jets shoot out great distances on the order of a million light years on each side. As the jets interact with the less dense intergalactic medium they eventually begin to disperse. The outer shells drawn denote the area in which this effect is felt. Most of the energy is due ultimately to gravity, the weakest of the physical forces (the others being electromagnetism, and the strong and weak nuclear forces). Material jets out and more material falls back into the rapidly rotating disk to perpetuate the process. When the density of this material drops below the level required to sustain the jets, they just go out leaving large radio lobes behind.

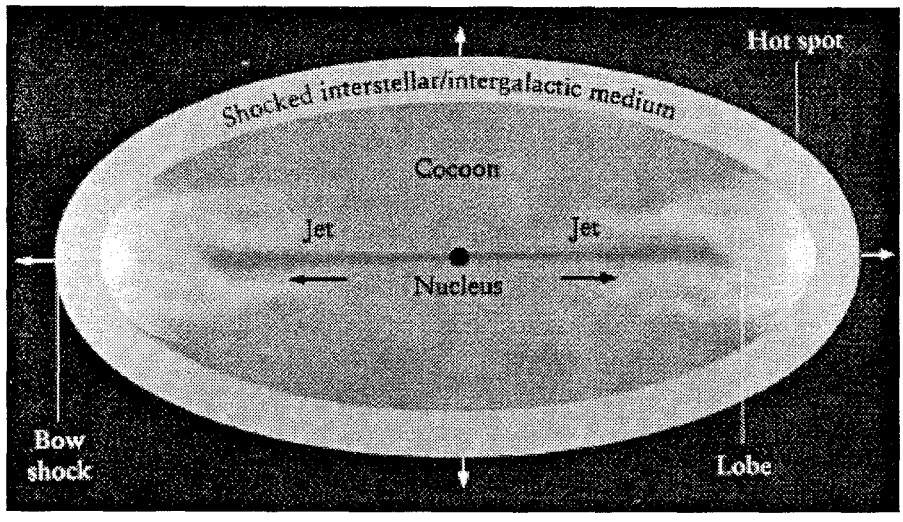


Figure 3) Schematic diagram showing the structure and mechanism of strong double radio sources. Most of the radio emission is producted in the "hot spots" and lobes, by jet material that has splattered against the interstellar or intergalactic medium. (From Scientific American Library's Gravity's Fatal Attraction.

We don't understand the precise mechanism but are beginning to get a general idea. A spinning black hole behaves like a spinning conductor. If the hole is surrounded by ionized, conducting gas carrying a magnetic field, then a voltage difference is set up between the poles and the equator, and the hole can act like a battery (*see* figure 4). The electric current driving the voltage drop can extract energy from the spin of the hole, which can be transformed into outflowing jets. It's worth pointing out that when one finds these electrons spiraling within a magnetic field producing synchrotron radiation, particles can well be moving close to the velocity of light. There might not be very much motion in the direction of the magnetic field, but it's quite possible to have very high velocities in the direction of the spiral.

It must be emphasized that few conclusions about radio galaxies can be made unless we can see in visual wavelengths the very faint galaxy in the middle of all these structures. All of our methods for measuring distance are based upon observations that are made in the very narrow spectrum of visible light. Without data compiled from visual wavelengths we can't measure distances, sizes, or the amount of energy involved. On the other hand if you can detect a faint galaxy in the middle of these structures you can measure out the red shift and if you know the Hubble constant for the expansion rate of the universe within a factor of 2, then you can begin to measure these quantities and begin to get a feeling for what is going on. This is why most of the work in radio galaxies in the 1960s focused on identifying these discrete galactic sources, to find a source in a visible wavelength that corresponds to a radio source. In fact, work being done today is focusing more and more on visible rather than radio wavelengths as larger telescopes and more sensitive detectors are enabling us to study the faint galaxies themselves.

It is interesting to note that when counts of radio sources have been performed (analogous to star counts) we find that dim radio galaxies are more numerous than bright radio sources. Counts of progressively dimmer radio sources yield progressively higher quantities of sources. If the strength of a radio source is any indication of distance (as visual magnitudes are for stars) then these results suggest that radio galaxies were much more common in the earlier days of our Universe than they are today. When the Universe was younger and denser, the conditions required to create black holes and the dynamics required to sustain a radio galaxy were much more favorable than they are now.

The study of radio galaxies in indicative of a really basic motivation to study astrophysics. Given the entire Universe as our laboratory we can study the dynamics of systems spanning millions of light years rather than the mere millionths of light seconds that we can create in our Earth bound linear accelerators. We can study 100 million solar mass black holes while the presence of even a small black hole at one of our observatories would produce irreconcilable difficulties. We can observe phenomena at scales that are far greater than anything that can be duplicated on Earth. Hence our wonder at the immense diversity in our universe and our humility in our ability to perceive it. ❍

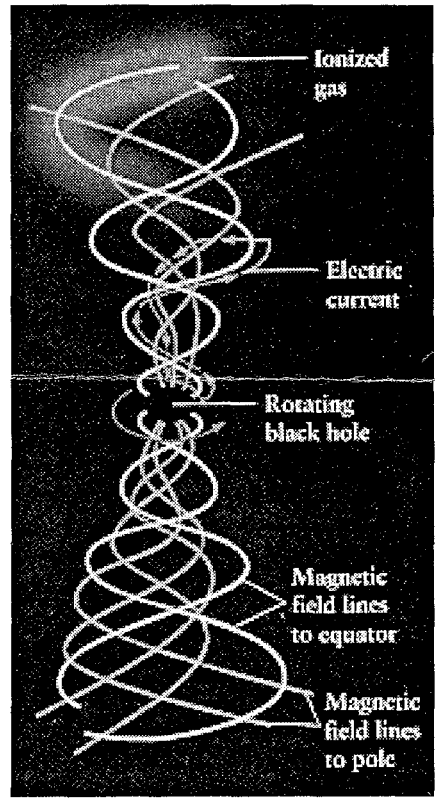


Figure 4) A spinning black hole behaves like a spinning conductor. If the hole is surrounded by conducting gas carrying a magnetic field, then a voltage difference is set up between the poles and the equator, and the hole can act like a battery. The electric current driven by the voltage drop can extract energy from the spin of the hole, which can be transformed into outflowing jets. (Credit: All four images come from the Scientific America Library, Gravity's Fatal Attraction.*)*

Mid-Atlantic Occultation Expeditions for the Rest of 1996

Lunar Grazing Occultations

DATE	Day	EST	Star	Mag	%	alt	CA	Location
Dec19	Thu	23:05	110328	7.2	78+	43	4N	Marlton & Temple Hills, MD; Alexandria,VA
Dec22	Sun	18:28	a.Tauri	0.8	96+	13	9S	s. of Gary, IN Sun alt. -2 deg.

Asteroidal Appulses and Occultations

DATE	Day	EST	Star	Mag	Asteroid	dmag	dur. sec.	ap. in.	Location
Dec07	Sat	22:36	G1853-1759	9.6	22 Kalliope	0.9	15	5	northern Florida
Dec10	Tue	19:37	pi Arietis	5.2	975 Persev.	9.5	7	1	Florida, Bermuda
Dec17	Tue	4:08	G2345-0183	9.0	704 Interamnia	1.6	30	5	Georgia, S. Carolina
Dec21	Sat	6:30	G0303-0485	9.7	13 Egeria	2.2	8	6	western Cuba
Dec26	Thu	20:42	PPM 240941	9.8	39 Laetitia	1.7	6	6	s.w. Canada
Dec28	Sat	6:32	SAO 078707	8.3	972 Cohnia	5.0	6	3	Kentucky, N. Carolina

Notes:
Dec. 22: The star is alpha Tauri (Aldebaran), the brightest star that can be occulted by the Moon.

Comet Hale-Bopp Countdown

By Daniel Costanzo

November Observations
This past November saw the incoming Comet Hale-Bopp (officially designated C/1995 01) faintly but definitely visible just after dark and within easy reach of both binoculars and the smallest of telescopes at dark-sky sites, and even at some suburban locations. I was able to easily view this fuzzy visitor from afar with binoculars on a mid-November night under a waxing, nearly First Quarter Moon at NCA's Elkwood, Virginia Field Station, a little over an hour's drive beyond the Beltway. In Celestron 8x56 binoculars, it was a small white puff with a short, faint tail with a length about three-quarters the angular diameter of the Moon. In a Celestron-8 telescope its center appeared as a quite "stellar" central point.

As of November 22, Hale-Bopp was continuing to hold its own, slowly "cooking" under increasing warmth from the Sun's fusion fire, and giving nothing but good omens for a bright spectacle early next year placing it within easy reach of unaided eyes. In brightness, in mid-November, the comet was in the mid-4th magnitude range and slowly getting brighter.

December Predictions
As December begins, Comet Hale-Bopp will be found steadily chugging Sunward, eating up almost two million kilometers a day of its comet-to-Sun distance. But at about 2.1 times Earth's distance from the Sun, or 2.1 astronomical units (AU) —320 million kilometers — a distance corresponding to roughly the Asteroid Belt's inner edge, Hale-Bopp still has quite a way yet to go before reaching "perihelion" (closest approach to the Sun) of 0.9 AU during prime viewing time early next April. (The AU is the common unit of Solar System measurement, where 1 AU is Earth's mean orbital distance from the Sun, or 149,597,870 kilometers. So 0.9 AU is just inside Earth's orbit, or about 135 million kilometers from the Sun, and between the orbits of Earth and Venus.) By December's end, that distance will decrease to about 1.8 AU. This means that come the New Year, Hale-Bopp will have finally entered what is called the Inner Solar System, as defined by an imaginary sphere centered on the Sun and extending to the planet Mars' farthest distance from the Sun.

Besides decreasing its comet-to-Sun distance, Hale-Bopp's comet-to-Earth distance is also slowly decreasing as both objects do an interplanetary ballet, causing the comet to continue a long slide toward "perigee" (closest approach to Earth) of 1.3 AU late next March. Between December's beginning and end, the comet's distance from Earth will shrink from 2.9 to 2.6 AU.

December is about the last month to get any kind of view of Hale-Bopp in the evening sky before it eventually gets temporarily swallowed up in twilight's glow come mid-December. Best viewing nights are in Moon-free skies during the first week or so of December. During this period, with the arrival of dark, the comet can be found only a few degrees up in the southwestern sky. After that, Hale-Bopp will be gone until mid-January when it reappears low in the morning twilight.

NCA Resources
Thanks to NCA, there's no reason why you should be kept in the dark about this

promising comet. Instead, we can put you in the dark watching it. If you wish more information on Hale-Bopp, consult *Sky & Telescope* magazine, especially its high quality finder charts. In particular, *see* the September issue (pages 72-73), October issue (page 67), November issue (page 71), and December issue (page 75). (*Sky & Telescope* is available to NCA members at a discount.) For further information via telephone recordings, call *Sky & Telescope*'s "Skyline" (617/497-4168). Via the World Wide Web, go the NCA's home page (http://myhouse.com/NCA/home.html). Bob Bolster (NCA) can also give expert, practical advice on viewing, photography, and electronic imaging (Phone: 703/960-9126, e-mail: 73257.507@compuserve.com). Bob can also provide customized listings and charts of comet positions, viewing times, etc.

Information and data for this article was obtained from Bob Bolster (NCA), and from "Skyline" for 1996 November 1, 8, and 22.

Telescope Shopping

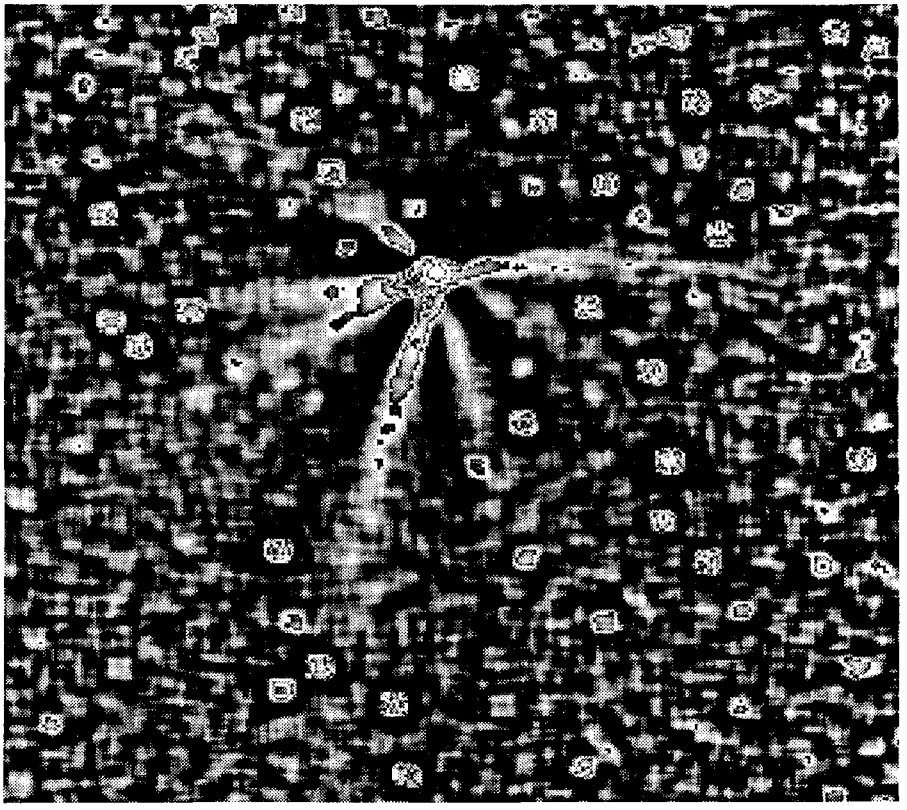
One word of warning for those in a seasonal buying mood contemplating purchasing a telescope for viewing Comet Hale-Bopp next year: You will be bombarded by advertisements for this or that instrument. Ignore them! The real rule about great comets is this: If you need a telescope to see it, then it isn't a great comet. Buy a pair of quality binoculars instead. An aperture (main lens diameter) of no less than 50 millimeters is ideal (e.g., 7x50). They're more suitable, a whole lot lighter, and most of all cheaper than an expensive telescope loaded down with unnecessary gizmos and doohickeys. But if you're heart is set on a telescope, then remember this: The attics of the world are filled with quality telescopes, unwanted and looking for homes. So consider a used telescope instead of a new one. Or as I like to say, an "astro-consumer tested" telescope instead of an untested one.

With proper care, quality binoculars and telescopes will last a lifetime, and beyond. NCA member Gary Hand (Astronomy By Hand) buys, sells, and trades quality binoculars, telescopes, and accessories, both new and used, at quite reasonable prices (Phone: 301/482-0000). He offers substantial discounts to NCA members. So call him soon. ❍

Seven Jets From Comet Hale-Bopp

European Southern Observatory Press Photo 37/96; September 20, 1996

This heavily processed image of C/1995 O1 (Hale-Bopp) is based on a CCD frame that was obtained on August 18, 1996, by Nick Thomas (Max-Planck-Institut fuer Aeronomie, Germany) and Heike Rauer (Observatoire de Paris, France), observing with the DFOSC multi-mode instrument on the Danish 1.54 meter telescope at La Silla, Chile. The frame was taken at 04:20 universal time (UT) through an R filter (to show the dust around the cometary nucleus) and the integration time was 20 seconds.



The subsequent image processing was perfomed by Hermann Boehnhardt (Universitaets-Sternwarte, Munchen, Germany). It involved bias subtraction and flat-fielding, followed by extraction of a subframe centered on the nucleus (the area corresponds to 797 x 797 pixels = 320 x 320 arc-seconds), logarithmic transformation and finally the application of a Laplace filter with a width of 15 pixels.

This procedure suppresses the smooth structure of the coma and enhances the visibility of the complex, non-symmetrical dust jet structure. No less than seven jets can be clearly seen, emanating from the nucleus. They are caused by the reflected sunlight in dust grains which are emitted from vents on the surface, due to the pressure of outstreaming gas.

At the time of these observations, Comet Hale-Bopp was 2.761 astronomical units (AU) from the Earth and 3.392 AU from the Sun. The appearance of the dust jet structures changed very little over a period of 3 nights, suggesting a long rotation period.

National Capital Area Astronomical Events

Free Lectures at the Einstein Planetarium and Other Daily Events
National Air & Space Museum

202/357-1550, 202/357-1686, or 202/357-1505 (TTY)
Home page: http://www.nasm.edu

Daily, 10:10 AM to 5:45 PM-"Langley Theater continuing movies, "To Fly," four shows starting at 10:10 AM; "Cosmic Voyage," four shows, starting 10:45 AM; "Destiny In Space," two shows, starting 11:30 AM; "Living Planet," one show at 3:50 PM; "Mystery of The Maya," one show at 5:45 PM. Details & Cost: *See* above numbers.

Daily, 11:00 AM-"SkyQest", Details & Cost: *See* above numbers.

Daily, 11:40 AM to 5:00 PM-"The New Solar System", Details & Cost: *See* above numbers.

Daily, 3:00 PM-"The Stars Tonight", *Free daily planetarium lecture/show.*

Through The Month of December-Something just for fun. A Special Space Fiction Film Festival: "Alien Encounters," 7:30 PM, Langley Theater, Saturday, December 7, "Invasion of the Body Snatchers"; Saturday, December 14, "Stargate"; Saturday, December 21, "War of the Worlds"; and Saturday, December 28, "Close Encounters of the Third Kind".

Other Area Astronomical Events

December 6, 13, and 20, 7:30 PM-"There's No Place Like Home," lecture by Howard B. Owen, Science Center (Lanham, MD). Details: 301/918-8750. Home Page: http://www/gsfc.nasa.gov/hbowens/hbowens_home.html.

December 6 through 22, Fridays and Saturdays, 7:30 PM, Sunday Matinees , 1:30 and 3:00 PM-Arlington Planetarium (Arlington, VA) lecture, "Tis The Season." A celebration of Holiday traditions past and present, of brilliant winter constellations, and a star. Details & Cost:703/358-6070 or 6019.

December 14, 7:00-9:00 PM-"Goddard At Night" sky watching program at Goddard Space Flight Center (GSFC—Greenbelt, MD) Visitors Center. Bring binoculars and telescope, or look through ones there. If cloudy, then presentation on astronomical topic. Details: 301/286-8981 (TDD 301/286-8103). Visitors Center Home page: http://www.pao.gsfc.nasa.gov.

Mondays Through Saturdays, 11:30 AM & 2:30 PM; 1st & 3rd Sundays of Month, 11:00 AM-GSFC (Greenbelt. MD) guided walking tours of Hubble Space Telescope Control Center and NASA Communications Center. Start at Visitors Center.

Mondays Through Fridays, 10:00 Saturdays and Sundays, 10:00 AM and 1:00 PM-Paul E. Garber Preservation, Restoration, and Storage Facility, NASM. Take a tour of this facility where they preserve and restore aircraft as well as spacecraft, engines, popellers, models, and other flight-related objects. Guide conducted tours including the workshops. Individuals and groups are welcome. Reservations must be made two weeks in advance. No heating or air conditioning so dress accordingly. Details: 202/357-1400, or write to ATTN: Reservation Office, Education Services Division, MRC-305, NASM, Washington, DC 20560.

"Deep Night" Periods For Star Viewing

Dan Costanzo's article on "Deep Night" periods will not be available this month. Dan has been sick. Look for his article to appear again in the January issue of *Star Dust*. If you are planning on stargazing and would like information, you can contact Dan at the numbers below. Information: Daniel Costanzo, 703/841-4765.

"Sky Watch"

Look for the "Sky Watch" column in *The Washington Post* "Style" section on the first Wednesday of each month. It lists many current events for the month.

"Observer's Handbooks"

Copies of the "Observer's Handbook" for 1997, published by the Royal Astonomical Society of Canada, will be on sale for $12 apiece at the December 7th NCA monthly meeting and at all subsequent meetings until they are sold out. Please bring a check made out to "National Capital Astronomers" rather than cash. If you wish to buy a copy but cannot attend the meeting, call Jeff Norman at 202/966-0739 to make arrangements for pickup. Thanks.

Newsletter Deadline for January *Star Dust* December 15, 1996

DO NOT BE LATE!!!

Send Submissions to Alisa & Gary Joaquin, at 7821 Winona Ct., Annandale, VA, 22003, Leave a message on voice mail 703/750-1636. Text files or graphic files in .GIF or .TIFF may be sent via E-Mail to ajglj@erols.com or fax submissions to 703/658-2233. **No submissions will be accepted after the 20th.** There will be no exceptions. We need a reasonable amount of time to design, edit, and review this newsletter. Though we have adequate time and resources to publish this newsletter, it is even more important this year to receive submissions on time. We would appreciate everyone's help in this matter. Thank you.

National Capital Astronomers, Inc.

SERVING SCIENCE & SOCIETY SINCE 1937

NCA is a non-profit, membership supported, volunteer run, public-service corporation dedicated to advancing space technology, astronomy, 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. All are welcome to join NCA. For information: 301/320-3621 or 703/841-4765.

SERVICES & ACTIVITIES:

Monthly Meetings feature presentations of current work by researchers at the horizons of their fields. All are welcome; there is no charge. *See* monthly *Star Dust* for time and location.

NCA Volunteers serve as skilled observers frequently deploying to many parts of the National Capital region, and beyond, on campaigns and expeditions collecting vital scientific data for astronomy and related sciences. They also serve locally by assisting with scientific conferences, judging science fairs, and interpreting astronomy and related subjects during public programs.

Discussion Groups exchange information, ideas, and questions on preselected topics, moderated by an NCA 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.

NCA Information Service answers a wide variety of inquiries about space technology, astronomy, and related subjects from the public, the media, and other organizations.

Consumer Clinics on selection, use, and care of binoculars and telescopes, provide myth-breaking information, guidance, and demonstrations for those contemplating acquiring their first astronomical instrument.

Dark-Sky Protection Efforts educate society at large about the serious environmental threat of light pollution, plus seek ways and means of light pollution avoidance and abatement. NCA is an organizational member of the International Dark-Sky Association (IDA), and the National Capital region's IDA representative.

Classes teach about subjects ranging from basic astronomy to hand-making a fine astronomical telescope. NCA's instructors also train educators in how to better teach astronomy and related subjects.

Tours travel to dark-sky sites, observatories, laboratories, museums, and other points of interest around the National Capital region, the Nation, and the World.

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, the Smithsonian Institution, the U.S. Naval Observatory, and others.

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

Fine Quality Telescopes up to 36-cm (14-inch) aperture are available free for member's use. NCA also has access to several relatively dark-sky sites in Maryland, Virginia, and West Virginia.

YES! I'D LIKE TO JOIN THE NATIONAL CAPITAL ASTRONOMERS

Enclosed is my payment for the following membership category:

[ ] Regular
- [ ] *Sky & Telescope* and *Star Dust.* ($51 per year)
- [ ] Star Dust only ($24 per year)

[ ] Junior (Only open to those under age 18) Date of birth: _____
Junior members pay a reduced rate.
- [ ] *Sky & Telescope* and *Star Dust.* ($42 per year)
- [ ] Star Dust only ($15 per year)

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First name Middle Last name Telephone

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Street or Box Apartment City State Zip

If family membership, list names of additional participating immediate family members in same household, with birthdates of all those under 18 years old: _____

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:

NCA c/o Jeffrey B. Norman, 5410 Connecticut Avenue, NW, Apt. #717, Washington, D.C. 20015-2837.

The following information is optional. Please indicate briefly any special interests, skills, education, experience, or other resources which you might contribute to NCA. **Thank you, and welcome to NCA!**

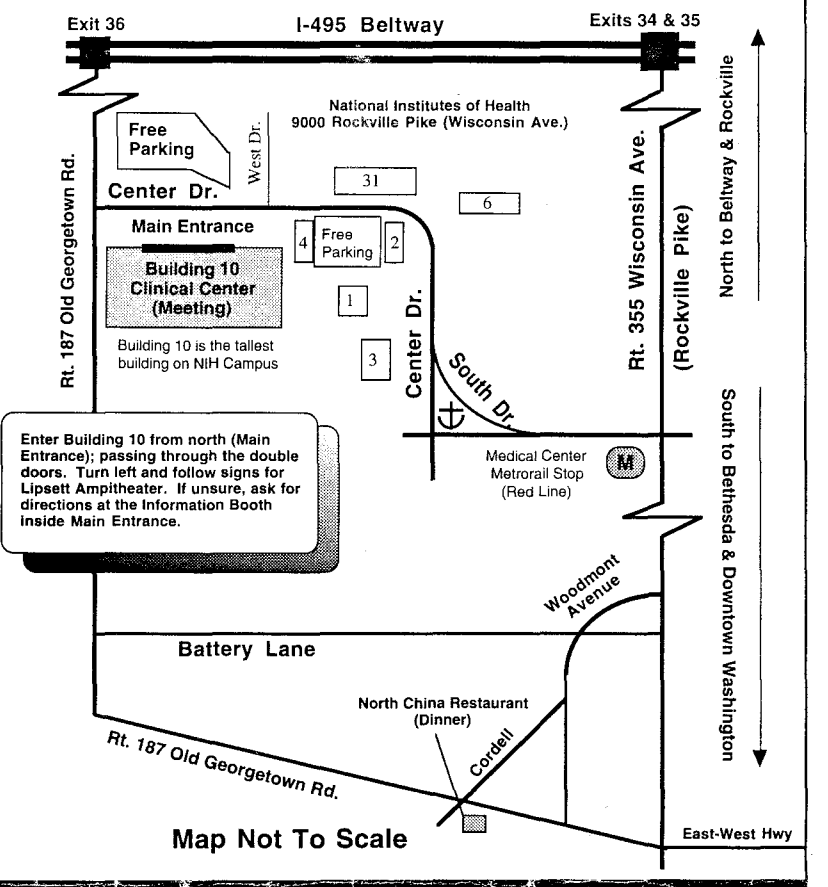
_____

_____

Getting to the NCA Monthly Meeting

Metrorail 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 (walking time about 10 minutes), the tallest 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 North China Restaurant - Take Wisconsin Avenue toward Bethesda and bear right onto Woodmont. Follow Woodmont to Old Georgetown Road and make a right. The restaurant is a few blocks on the left (7814 Old Georgetown Road). Alternatively, turn right on Cordell from Woodmont and proceed a few blocks to Old Georgetown, where you will come out right near the restaurant. There is parking around the corner on a side street.



Star Dust **is published ten times yearly (September through June) by the National Capital Astronomers, Inc. (NCA), a nonprofit, astronomical organization serving the entire National Capital region, and beyond. NCA is the astronomy affiliate of the Washington Academy of Sciences and the National Capital region's representative of the International Dark-Sky Association. NCA's Phone Numbers: 301/320-3621 or 703/841-4765. President: Harold Williams, 301/565-3709. Deadline for *Star Dust* is the 15th of the preceding month. Editors: Alisa & Gary Joaquin, 7821 Winona Ct., Annandale, VA 22003, 703/750-1636, E-mail: ajglj@erols.com. Editoral Advisor: Nancy Byrd.**

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