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The Story of Vulcan

by Leonard B. Abbey, F.R.A.S.

Leonard Abbey is a member of the Atlanta Astronomy Club and the following is reprinted with his permission.

The great impetus given to planetary astronomy by the discovery of Uranus in 1781, the major asteroids in 1801–4, and Neptune in 1845 spurred many astronomers to turn their attention to this field. Theoretical work done by the great French mathematician Leverrier had been a prime factor in the discovery of Neptune by Galle in Berlin. In fact, his calculations had been the sole cause of that discovery. (Of course, the English mathematician John Couch Adams had made similar calculations which pre-dated the Frenchman's work, but Adams' predictions were ignored by Astronomer Royal Airy until after Galle had discovered Neptune — using Leverrier's work.) A little taste of the fame associated with the discovery of a new planet goes a long way, and Leverrier began to look for new possibilities.

The unexplained advance of Mercury's perihelion soon attracted him. He deduced that this advance could be explained by either assuming Venus to be 1/10th more massive than had been thought, or by postulation an intra-Mercurial planet. By this time the relative masses of all known major members of the solar system had been worked out to a reasonably accurate degree, so Leverrier began to investigate the possibility of another planet. In 1859 he published his preliminary findings. In response to Leverrier's paper, a physician and amateur astronomer named Lescarbault announced that he had observed the passage of an object, which he took to be the new planet, across the sun's disk. A minor earthquake shook the astronomical world. Many observers wrote excitedly to the reticent doctor seeking further information, but he was reluctant to reply to such correspondence pending more definite results. Being unable to communicate with Lescarbault in any other way, Leverrier journeyed to Eure-et-Loire to seek a personal interview.

At that time Leverrier was the lion of the European intellectual community, and was highly aware of his fame and achievements. As a matter of fact, he was known to be rather egotistical and pompous. Imagine Lescarbault's surprise upon answering his door when he was confronted by this arrogant and angry man, who refused to identify himself, and began as follows: "It is then you, sir, who pretend to have observed the intra-Mercurial planet, and who have committed the grave offense of keeping your observations secret for nine months. I warn you that I have come here with the intention of doing justice to your pretensions, and of demonstrating that you have been dishonest or simply deceived. Tell me then, unequivocally, what you have seen." Lescarbault then proceeded to show his equipment to Leverrier. This consisted of a small refractor (the typical, and very expensive, amateur instrument of the day), a pocket watch showing only hours and minutes and a seconds pendulum (the equivalent of our modern stop watch). All calculations had been made on a wooden board, the surface of which was cleared for new calculations with a small hand plane. Despite the modesty of the equipment Leverrier came away convinced the observations had been accurately made, and that the suspected planet had been observed. He congratulated Lescarbault on his discovery and named the new planet Vulcan. From Lescarbault's single observation, Leverrier obtained the following data:

Longitude of Ascending Node 12º59'
Inclination of Orbit 12º10'
Semi-major Axis (Earth=1) 0.143
Daily Heliocentric Motion 18º16'
Period 19 days 17 hours
Mean Distance from Sun 13,082,000 miles
Apparent Diameter of Sun from Vulcan 3º36'
Greatest Possible Elongation 8º

Leverrier's work was now ready for its final test: a second, predicted, observation. Astronomers at major observatories were alerted and anxiously awaited the great event. Alas, Vulcan failed to show up for its scheduled passage across the sun's disk.

After 127 years Lescarbault's observation remains unconfirmed. Numerous sightings of unexplained objects transiting the sun have been reported since 1860, but none of them appear to be consistent with an intra-Mercurial planet. Sightings of unexpected star-like objects in the immediate region of the sun during solar eclipses have been reported, notably by Watson and Swift in 1878, but

these observation agree neither with theory nor with each other.

Belief in Vulcan began to wane by 1880. It is possible that some of these sightings were transits of the nuclei of sun-grazing comets. Many comets which encounter the sun are never observed from earth because they both approach and recede from that part of the sky which is behind the sun from our viewpoint. This is evident from the fact that many comets have been observed during solar eclipses but are never seen otherwise. However there is no authenticated observation of the transit of a cometary nucleus across the sun's disk.

Leverrier maintained his belief in Vulcan for the rest of his life. Shortly before his death in 1877 he wrote: "There is, without doubt, in the neighborhood of Mercury, and between that planet and the sun, matter hitherto unknown. Does it consist of one, or several small planets, or of asteroids, or even of cosmic dust? Theory cannot decide this point."

Theory did decide the point, though not in a manner which Leverrier, in spite of his undisputed genius, could have conceived. The Theory of Relativity, first published in the early years of this century, has special meaning for the Vulcan problem. As with other planets, the orbit of Mercury is essentially a perfect ellipse. The direction in which this ellipse is tilted rotates slowly about the sun. The shape of this orbit, as well as the rate at which it rotates around the sun, is determined by the mass of the planet, the mass of the sun, the planet's distance from the sun, and by the perturbations caused by the other bodies of significant mass in the solar system. Astronomers of the late 19th century thought that they were aware of all these factors to a great degree of accuracy, and thus the positions of the planets could be predicted fairly precisely, well in advance.

This was true with one exception. The exception was Mercury, where the rate of advance for the perihelion could not be reconciled with the most careful predictions. According to Einstein, the presence of a strong gravitational field requires the addition of new terms to the equations describing space and time, which were unknown to Newton and the other founders of celestial mechanics. Mercury is the only planet whose orbit lies sufficiently close to a very massive body (the sun) for these new considerations to be measurable. The net effect is that the Newtonian formulas, when refined by the relativistic terms, predict an advance of Mercury's perihelion exactly equal to that observed over the centuries. In fact, this is one of the three classical tests of the theory of relativity.

Once again our knowledge of the solar system had been advanced by a man sitting at a table, working with only a pencil and paper! Nevertheless, the lure of such an appealing subject as an undiscovered planet, even within the orbit of Mercury, will probably never die out. It is possible, even probable, that there are very small bodies (or cinders!) revolving in the hellish intra-Mercurial region. Some of them are most certainly man-made. What is definite, however, is that they will never be observed from earth, whether in transit across the sun, during a total eclipse, or at elongation.

The case book for Vulcan is closed. Leverrier and Lescarbault are not to be criticized for their honest and scientific approach to a very serious problem. Though they did not live to see their theory disproven, they realized, as we do, that failure to seek is the destroyer of progress.

Astrophoto IX Seminar

March 30th 1991

This seminar, held every other year, covers all aspects of celestial photography with information for beginning and advanced astrophotographers. There will be lectures on Astronomy and Astrophotography, photo exhibits, and information on new equipment and techniques.

Registration at the door is (includes proceedings) $25. Mail ordering of proceedings only is $15. For more information contact either SAC's Gene Lucas (934–1889) or Ventura County Astronomical Society.

Make checks payable to VCAS/Astrophoto IX. Mail to:

Ventura County Astronomical Society
P.O. Box 982
Simi, Ca 93062

Comet Comments

by Don Machholz

Two new comets have been found recently, with one more recovered.

Comet Metcalf-Brewington (1991a): Howard Brewington of New Mexico discovered this comet on Jan. 6 with a 16" reflector. This find, occurring on the last sweep of a cold three-hour session, came 165 hours after Howard's previous find some fourteen months ago.

As the orbit was determined, it was realized that this is Periodic Comet Metcalf, discovered in 1906 and not seen since. Its orbital period is 7.76 years, and, although three out of every four passages is favorably placed, it had not been observed since 1906. Apparently it flared shortly before Brewington picked it up, pre-discovery photographs taken Jan. 5.5 UT show it at magnitude 15. In the hours after Brewington spotted it, T. Kiuchi of Japan and William Bradfield of Australia picked it up.

The discovery position was within three degrees of the position predicted by John Rogers and Charles Townsend in their booklet **Predictive Ephemerides for Selected One-Apparition Periodic Comets**. The predicted magnitude was 17, which is probably near where the

comet generally resides. The comet reached perihelion on Jan. 5 at 1.59 AU and is now pulling away from both the Sun and Earth.

Comet Arai (1991b): Masaru Arai of Japan photographically discovered this comet on Jan. 5 at magnitude 10.5, a few degrees SE of M44 and Jupiter. It was closest the Sun on Dec. 10 at 1.4 AU, it is now dimming as it heads into the N. Polar region.

Periodic Comet Swift-Gehrels (1991c): T. Seki of Japan recovered this comet on Jan. 7 at magnitude 17. It will not get much brighter.

Comet	**Metcalf-Brewington**				**(1991a)**
Date	RA-1950-Dec	RA-2000-Dec	Elong	Sky	Mag
02–23	02h13.4m +03°27'	02h16.0m +03°41'	60°	E	9.2
02–28	02h27.0m +04°29'	02h29.6m +04°42'	58°	E	9.3
03–05	02h40.6m +05°29'	02h43.2m +05°41'	57°	E	9.4
03–10	02h54.1m +06°26'	02h56.8m +06°39'	55°	E	9.5
03–15	03h07.6m +07°21'	03h10.3m +07°33'	54°	E	9.6
03–20	03h21.1m +08°14'	03h23.8m +08°24'	52°	E	9.7
03–25	03h34.4m +09°03'	03h37.1m +09°13'	51°	E	9.8
03–30	03h47.7m +09°48'	03h50.4m +09°58'	49°	E	9.9
04–04	04h00.9m +10°31'	04h03.6m +10°39'	48°	E	10.0
04–09	04h14.0m +11°09'	04h16.7m +11°17'	46°	E	10.1

Comet	**Levy**				**(1990c)**
Date	RA-1950-Dec	RA-2000-Dec	Elong	Sky	Mag
02–23	09h35.6m −14°15'	09h38.0m −14°29'	153°	M	8.4
02–28	09h18.3m −09°58'	09h20.8m −10°10'	153°	E	8.6
03–05	09h03.7m −06°00'	09h06.2m −06°12'	149°	E	8.9
03–10	08h51.6m −02°27'	08h54.1m −02°38'	143°	E	9.1
03–15	08h41.7m +00°40'	08h44.3m +00°29'	137°	E	9.3
03–20	08h33.8m +03°22'	08h36.4m +03°11'	130°	E	9.6
03–25	08h27.7m +05°41'	08h30.3m +05°31'	124°	E	9.8
03–30	08h23.0m +05°40'	08h25.7m +07°30'	117°	E	10.1
04–04	08h19.6m +09°21'	08h22.3m +09°11'	112°	E	10.3
04–09	09h17.2m +10°48'	08h19.9m +10°39'	106°	E	10.5

Bits and Pieces

March's Speaker

The speaker for March will be Pera Aannestad, Associate Professor at ASU Department of Physics. He received his PhD from Berkeley and is involved in theoretical studies of the interstellar medium, properties of interstellar dust, and infrared astronomy. His topic will be "Gases and Dust among the Stars."

Minutes of the January Meeting

President Paul Lind called the meeting to order at 7:30pm. The first of business was introducing the new officers for 1991. Bob Dahl then presented the treasurer's report. Next on the agenda was the schedule for upcoming events. A.J. Crayon gave an update on the Deep Sky subgroup. Steve Coe talked about the next novice's group meeting scheduled for April with the subject being astrophotography. For old business the donation for the International Dark Sky Association was tabled until the budget is worked out. For the Show-N-Tell portion Chris Schur showed slides of his recent work; Pierre Schwaar presented video of Mars, Jupiter and the Moon; and Dan Ward showed slides using the slide film Scotch 800.

The main speaker was club member Pete Burggraaf. His talk was titled "Harquahala: Arizona's forgotten Observatory." His very interesting talk dealt with the solar observatory operated by the Smithsonian in the Harquahala mountains west of Phoenix in the mid 1920's. —*Phil Dahl, SAC Secretary*

Minutes of the February Meeting

President Paul Lind called the meeting to order at 7:30pm. First on the agenda was upcoming events (see the attached calendar). Treasurer Bob Dahl then presented the Treasurer's report. The May meeting data was changed to May 31st so as to not conflict with Riverside. Paul briefly shared the results of the board meeting held Jan. 28th. Paul Dickson then solicited input on questions for the SAC survey. For the Show-N-Tell Tom Polakis showed his latest work with wide-angle astrophotography and Chris Schur presented pictures guided with the SBIG St4 CCD camera and guider. A.J. Crayon then gave an updated on the Deep Sky subgroup and handed out observing awards.

The main speaker was club member Paul Knauth. His talk centered on professional slides taken by Malin and the European Southern Observatory with commentary on what the objects were and what was occurring. —*Phil Dahl, SAC Secretary*

1991 SAC Meetings	**1991 SAC Star Parties**
March 1	March 9
April 26	April 6
May 31	May 4
June 21	June 8
July 26	July 6
August 23	August 3
September 20	September 7
October 25	October 5
November 22	November 9
December 14 Party	December 28

Deep Sky Meeting

The Deep Sky meeting will take place on Thursday, March 7 at 7:30pm. See the directions on the first page. A discussion about the following objects in the constellation Monoceros will be held: Rosette nebula, Hubble's Variable nebula, M 50, NGC 2301, IC 2177, and the double stars β, ϵ, and KS.

Public Star Parties

There will be a public star party at Reach 11 on April 20th. Reach 11 is just north of Union Hills on Tatum Blvd.

There will be another public star party in May at Thunderbird park.

Coming Soon

Tentatively planned for Sunday afternoon, April 28th, is a beginner's astrophotography meeting.

Directions to SAC Events

SAC General Meetings 7:30 PM at Grand Canyon University, Fleming Building, Room 103 — 1 mile west of Interstate 17 on Camelback Rd., north on 33rd Ave., second building on the right.

SAC Star Parties at Buckeye Hills Recreation Area — Interstate 10 west to Exit 112 (30 miles west of Interstate 17), then south for 10.5 miles, right at entrance to recreation area, one-half mile, on the right. No water and only pit toilets. Please arrive before sunset; allow one hour from central Phoenix.

SAC Deep Sky Subgroup Meeting at John & Tom McGrath's, 11239 N. 75th St., Scottsdale, 998–4661 — Scottsdale Rd. north, Cholla St. east to 75th St., southeast corner.

Skyshooting Comets

A Challenge for Astrophotographers

By Chris Schur

Part 1

The appearance of a bright comet in the evening sky can stir the sense and wonder in even the most unresponsive individuals. Astronomy clubs really come alive and the "dormant" armchair individuals dust off their old scopes in their closets. But for the astrophotographer, the ability to capture the shortlived beauty of these transient visitors on film and to do it right taxes the skills of even the most persistent astrophotographers. In this first part of a series of articles, I shall present various methods which I have found to be successful to capture these ghostly visitors on the emulsion, along with tips and suggestions for using your equipment to obtain the best results.

Comets offer a special challenge to the deep sky photographer. Their tremendous variability in size, brightness, and internal structure makes it impossible to shoot them with only one camera lens or telescope or even a single type of film. Often the brightness difference between the tail and coma is so great as to make printing them in the darkroom a compromise. These difficulties can be for the most part overcome, and with special tracking procedures outlined later, you will find that we can push our telescopes to their limits and record every bit of detail the comet will offer.

Average Comets

These range in magnitude from about five to nine and typically two or three per year appear. Many can be seen to varying degrees in a pair of 11x80's, but the best views are always through the telescope. Consequently, shots through the main optics at prime focus reveal the most details. Average comets can have up to a degree or two of tail, or maybe none at all. If a tail is suspected, it is best to frame up the comet in the viewfinder such that the possible tail will stretch the diagonal in the frame with the head nearly in the corner. Stoping down your fast Newtonian to $f/5$ or $f/6$ will reduce the vignetting in the corners to a negligible amount such that good detail and brightness is retained across the entire field.

As far as movement during the exposure, comets can provide a special challenge. Brighter comets are closer to the Sun or Earth, and hence their daily motion across the sky is more than distant comets. Either special tracking procedures or possibly the use of fast hypered films for short exposures (5–10 mins) can record them as nearly stationary objects. The good news here is that these brighter objects usually show some degree of color on the film, usually bluish or greenish, and are well worth shooting on color emulsions.

The details you will record will vary greatly with the object, but in general the inner coma and bright nuclear region are best recorded on a finer grained color emulsion. This is because of the wide latitude of brightness densities that can be recorded on a color negative film which will show more than a burned out core. Look for distinct brightness zones in the coma, color variations, and jets from the nucleus. The faint tail, if any, is always recorded with a higher contrast black and white emulsion. This will reveal any rays, knots and dark zones behind the head that might be present.

Tracking on a Comet's Motion

Most comets will require a long enough exposure such that you must allow for it while taking the exposure. The two easiest ways to do this, with the least amount of equipment modifications, is to guide on an available nearby bright star with a transit eyepiece. Since nearly all comets nuclei are too faint for high magnification guiding, the offset method offers the best hope. We constructed a reticle on 1/16 inch plexiglass with the pattern of evenly spaced scribes on one axis of the crosshair moving away from the center. The idea is to find the scale of the spaces of the tick marks on the reticle by timing a star's drift across the pattern with the drive turned off. A new comet's motion is calculated in degrees per day and the position angle by measuring the movement of the angle directly off the Tiron chart. Next we calculate the comet's motion during the exposure and advance the guide star in the opposite direction during the exposure by the same amount the comet will move. The end result is the comet sits still on the film and the stars trail an amount the comet would have moved on a standard tracked shot.

Skyshooting comets offers a challenge to astrophotographers unlike that of the usual deep sky targets. The fact that they all move against the background stars at different rates and in curving paths should not discourage the determined amateur.