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Near-Earth Asteroid Discovery Rate Review, Eleanor F. Helin, Jet Propulsion Laboratory

Fifteen to twenty years ago the discovery of 1-2 Near-Earth Asteroids (NEA's) per year was typical from one systematic search program, Palomar Planet-Crossing Asteroid Survey (PCAS), and the incidental discovery from a variety of other astronomical programs. Sky coverage and magnitude were both limited by slower emulsions, requiring longer exposures. The 1970's sky coverage of 15,000 to 25,000 sq. deg. per year led to about one NEA discovery every 13,000 sq. deg.

Looking at the years from 1987 through 1990, we find that by comparing 1987/1988 and 1989/1990 the worldwide discovery rate of NEA's went from 20 to 43, a little more than a twofold increase from the first two year period to the latter two years. More specifically, PCAS' results when grouped into the two year periods, show an increase from 5 discoveries in 1987/1988 to 20 in the 1989/1990 time period, a fourfold increase. Also, that our discoveries went from representing about 25 percent of the worldwide total to contributing roughly 50 percent of the discoveries worldwide in the 1989/1990 period. This trend continues into 1991, whereby PCAS is discovering about a NEA per month. As the discovery rate continues to spiral up, with significant contributions coming from McNaught/Steel in Australia and Gehrels, Scotti and Rabinowitch in Arizona, I anticipate a doubling again in discoveries in the 1991/1992 period. Of course, an important aspect of these more recent discoveries is the inclusion of fainter than magnitude 20-21 objects extending out as faint as H magnitude 28 (1991 BA). At the same time several very bright asteroids have been discovered which indicates that in the NEA population not all of the objects to magnitude 13-14 have been discovered. The PCAS discovery of the 1990 SQ at H magnitude 12.5 surpasses (1627) Ivar as the brightest known asteroid in the NEA population. It is rather remarkable that our most recent NEA discoveries in 1990/1991 include the brightest (1990 SQ) and the faintest (1991BA) on record, certainly suggesting that a wide range of undetected objects still roam in earth-approaching and crossing orbits. The surge of discoveries enjoyed by PCAS in particular is attributed to new fine grain sensitive emulsions, film hypering, more uniformity in the quality of the photograph, more equitable scheduling, better weather, excellent team members and coordination of efforts. Although one hopes that more improvements and fine tuning may be possible, it seems that we have just about attained our maximum output for the discovery of NEA's using current techniques at the 0.46 M Palomar Schmidt. I anticipate working diligently to maintain our current rate of discovery. Significant increase in discoveries in the next two year period will most likely come from elsewhere (the southern hemisphere and fainter, smaller objects found by CCD - electronic sensor detector-facilities). With the stunning increase in the last 2 year period over the previous two years, an order of magnitude, if not greater, increase in the discovery rate of NEA's can be anticipated by the end of the decade with the advent of CCD Schmidt Telescopes distributed around the world.

I wish to thank Palomar Observatory for observing time and necessary support. This research was carried out in the Planetary/Astronomy programs at Jet Propulsion Laboratory, California Institute of Technology, under contract with National Aeronautics and Space Administration.

SPECTROSCOPIC OBSERVATIONS OF COMET AUSTIN (1989c)

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Terry Rettig, University of Notre Dame
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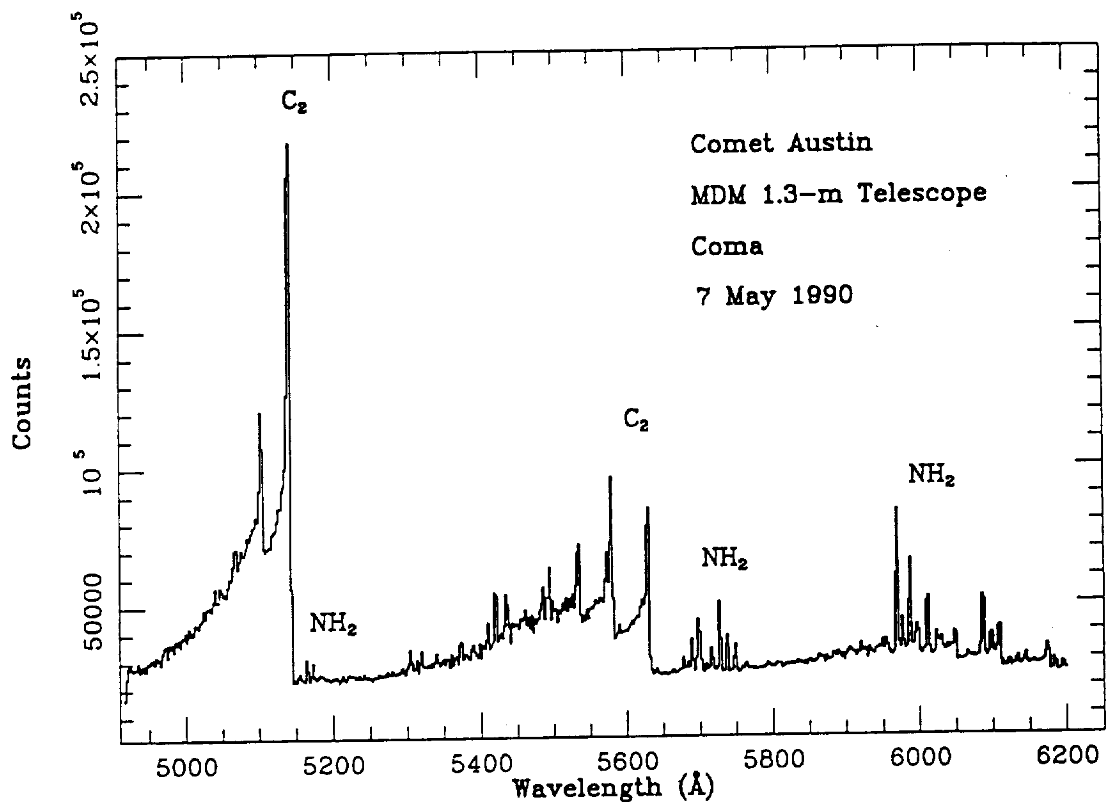
Longslit CCD spectra($\lambda = 5100 - 6400$ Å, $\Delta\lambda \sim 3$ Å) were obtained with the Michigan-Dartmouth-MIT 1.3 meter telescope in May 1990($r = 0.74$ AU, $\Delta = 0.50$ AU). The spectra have been reduced with IRAF. Spectral extractions offset sunward and tailward from the nucleus were analyzed. Species observed in the spectra include: C_2, NH_2, H_2O^+, CO^+, and several unidentified features. Spatial extractions of rotational lines in the NH_2(10-0) band extend $\sim 10^{4.5}$ km from the nucleus. A fit of the vectorial model to the NH_2(10-0) spatial profile is consistent with an NH_3 parent molecule. The NH_2 production rate and an ammonia to water abundance ratio have been derived.



IR Spectroscopy of Comets: Methanol at 3.52 μm

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As part of an ongoing program to use infrared spectroscopy to search for molecular species which are directly sublimated from cometary nuclei, we present medium resolution ($\lambda/\Delta\lambda \approx 10^3$) long-slit spectra of several recent comets in the 3-μm region. In the 3.44-3.64 μm spectral region, we detect the red wing of the broad "organic" feature which is centered at 3.36 μm, and a narrower feature is apparent which peaks at 3.52 μm, which we tentatively identify with methanol. We find that the spatial profile of the 3.52-μm emission is consistent with that of a directly sublimated species. We will compare our results with the detections of methanol and formaldehyde in comets at millimeter wavelengths. We will report upper limits for formaldehyde retrieved from our spectra, and we will discuss the implications of a possible extended source of H_2CO on our results.

LIGHT CURVE DERIVATIVES AS A TOOL FOR THE ANALYSIS OF ASTEROID REFLECTION PROPERTIES, M. Hoffmann, Observatorium Hoher List, Universitäts-Sternwarte Bonn, Daun, F. R. Germany

Signatures of the collisional origin, subsequent cratering, and of albedo variegation show up in the light curves of asteroids, but it is impossible to separate these effects by a light curve inversion uniquely. For smooth ellipsoidal and multifractal surface models as well as for several aspects of the asteroid 7 Iris some characteristic properties of their rotation light curves are shown by a spectral analysis of their derivatives. Contrary to light curve analysis techniques involving spherical harmonics the high frequencies of their brightness changes are utilized by this method.

U.S. GEOLOGICAL SURVEY-LOWELL OBSERVATORY ASTEROID SURVEY: FIRST RESULTS; H.E. Holt, USGS, Flagstaff, Ariz., E. Bowell, Lowell Observatory, Flagstaff, Ariz., C.S. Shoemaker and E.M. Shoemaker, USGS, Flagstaff, Ariz.

Each year during the course of the asteroid and comet survey conducted by us at Palomar, about 1,000 fields, 8.75 degrees in diameter, are photographed with multiple exposures on hypered Kodak 4415 film. Under favorable conditions of observing, the detection threshold for main belt asteroids is about B = 18.5. Single fields near opposition may contain more than 100 asteroids, most of which are new. Altogether, several thousand asteroids are found and marked on the films each year. Until recently, because of limited manpower, astrometry was carried out only for a modest number of objects, chiefly planet-crossing asteroids, Trojans, high inclination asteroids, and comets.

A systematic effort was begun in the fall of 1990 to complete astrometry for the majority of asteroids observed in selected months. The immediate objectives of this pilot effort are to update the orbits of numbered asteroids, to extend the orbital arcs of previously designated objects and search for linkages, and to determine orbital elements for numerous new asteroids. To date, asteroids observed in 50 fields have been measured on 2 to 3 pairs of films separated by 2 to 6 days during a single dark run. More than 2,000 asteroids have been measured; among those, 820 objects were initially regarded as new asteroids. We are attempting to obtain at least one-month arc orbits for as many of the new objects as possible. So far, updated orbits have resulted for about 200 numbered asteroids; improved orbits have been obtained for about 100 unnumbered asteroids, of which about 20 have now been numbered. New short arc orbits were derived for about 300 asteroids from our observations; in many cases it has permitted the linkage of previously designated asteroids, resulting in multiple opposition orbits. A few of the new objects have already been numbered.

Our principal objective in this investigation is to substantially increase the rate of discovery and of numbering of main belt asteroids. Our long range goal is to double or triple the number of main belt asteroids with high precision orbits in order to resolve questions concerning the dynamical structure of the belt. In particular, we are interested in the identification of collisional families. The present statistics of proper elements are sufficient to recognize only large families with high confidence. Greatly expanded knowledge of the asteroid belt is required to demonstrate the reality of small families and thereby document many specific events in the collisional history of the belt.

ORIGIN OF ASTEROIDS AND COMETS

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The physico-chemical conditions of the nebular disk around the sun,especially the temperature profile, caused the asteroid region to be a transition region between non-condensation and condensation of ice-matter, resulting in a discontinuity in the projected surface density of solid acrretable matter. Because the ice-matter can condense in the Jupiter region and there was more acrretable matter, large planetesimals formed very early and grew rapidly. The mutual perturbation and encounders of these planetesimals changed their orbits,making some of them pass through the asteroid region. At that time, the planetesimals in the asteroid region were still small, so the interlopers accreted and took away with them the local accretable matter, causing the local planetesimals to stop at the "half-finished product" stage, forming only asteroids and not major planets. Perturbation by interlopers also increased the random velocity of the local remant planetesimals and their break-up through mutual collision gave rise to the great orbital veriety of asteroids and their mass spectrum. this basic view is proved by quantitative analysis, including accretion of Jet streams.

The structure in the outer region of the nebular disk is analysed and no formation zone of comets can exist there. Our view is that the comets evolved from the residual ice-planetesimals in the zone between Jupiter and Nepture.

ANALYSIS OF MEI VILLAGE FALLEN ICE

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A piece of ice fell down from the sky into a field near cottage Chen Shan Fang of Mei village,Wu-Xi county in China,on 17 november 1984. By investigating the scene of the fallen ice and witnesses and departments of meteorology and aviation, possibilities that the ice was of artificial or meteorological or airplane origins was excluded. A few samples of the ice were submitted to serious experimental analysis, and preliminary results show that there are some differences between the ice and terrestrial matter. It is in favour of the viewpoint that the ice originated from extraterrestrail space, maybe from a small comet. Further researching fallen ice might be of great significance for understanding nature of comets and water resource on the earth as well as relevant problems of meteorology, geology and astronomy.

METALLIC ATOMS AND IONS IN COMETS

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Investigation of metallic component in comets is important in different aspects. Emissions of refractory metallic atoms (Fe, Ni, Si, etc.) have usually been detected in Sun-grazing comets at heliocentric distances $R \approx 0.01$ AU. Meanwhile, in situ measurements carried out withing the coma of comet Halley 1986 III by VEGA and GIOTTO spacecraft near R=1 AU led to the discovery of metal ions of the Fe^+ type.

Anomalous distribution of the Na D-line emissions in the head of the bright comet Mrkos was detected by 200-inch Palomar telescope in 1957, the origin of which is the puzzle in the physics of comets.

Metallic atoms have the low ionization potentials and in this connection the short photoionization time scale ($\sim 10^4$ sec at R=1 AU) so that generation mechanisms of metal atoms may also by important in the problem of the ionization of the cometary matter, particularly of the inner coma.

Theoretical considerations of the different mechanisms of generation of metal atoms and ions in the cometary comae led to the following conclusions. Depression of the temperature of the cometary dust - of the potential source of cometary coma metallic component - by the outflowing cryogenic gas from the cometary nucleus may occur in the near-nuclear region of bright comets and therefore the gas production rate of such comets may be determined on the basis of anomalous distribution of the sodium D-line emissions.

Ions of refractory elements (Fe^+, Si^+, etc.) in the cometary coma at large heliocentric distances will be effectively produced by high velocity ($\gtrsim 10$ km/s) collisions of cometary and zodiacal dust particles and therefore such metallic ions may serve as indicators of the passage of dusty comets of the Halley type through interplanetary dust clouds.