THE COMET – ASTEROID TRANSITION : RECENT TELESCOPIC OBSERVATIONS

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Abstract. The phenomenon of a comet-asteroid transition presents the opportunity to study the comet reservoir in comparison to that from which asteroids are derived and to understand the evolution of comets. I discuss six significant areas which have impacted understanding of the comet-asteroid transition from recent years : new discoveries, discovery of dust and volatile comae at 2060 Chiron, observations of comet nuclei, observations of extinct-comet candidates, observations of dust trails associated with short period comets, and discovery of a dust tail on a prediscovery image of 4015 Wilson-Harrington. It is currently possible to recognize an object only as either a comet or an asteroid. There is currently insufficient information to recognize dormant or extinct cometary nuclei, though this is certainly the major goal being sought.

1. Introduction

The objectives of studying the comet-asteroid transition are two-fold, to understand the differences in the composition of the comet and asteroid reservoirs, relating that information back to the formation of the Solar System, and secondly, to understand the evolutionary path of comets in terms of both dynamics and physical properties. I find it useful to review the definitions of comets and asteroids in the manner that was done in Hartmann *et al.* (1987) and Weissman *et al.* (1989). I have reworded the definitions to emphasize what I think is important, the different parts of the Solar System from which the two types of bodies formed.

1. **comet** : a body formed in the outer Solar System. Subsets of comets include the following :
   a. *active comet* : a comet losing volatiles and dust with a detectable coma.
   b. *dormant comet* : a comet with a nucleus which has essentially no volatile loss and hence no detectable coma, though it is active sometimes.
   c. *extinct comet* : a comet that has lost all volatiles.
2. **asteroid** : an interplanetary body that formed in the reservoir between Mars and Jupiter.

Reviews of related topics have been presented in recent years. Wetherill (1991) reviewed the dynamical mechanisms by which comets evolve into dormant or extinct states. The timescales for their evolution into asteroidal orbits is one to two orders of magnitude longer than the time scales of cometary volatile activity, thus making the existence of dormant or extinct comets plausible. Observational scientists are now and have been looking for physical evidence of the evolution of a comet into an object with asteroidal properties with some success but there are also remaining

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questions. I will review the significant observational findings of the past five years concentrating on results since the last ACM meeting in Flagstaff, 1991.

There are six significant aspects of observational studies contributing to our understanding of the phenomenon of the comet-asteroid transition :

1. New discoveries of objects in comet-like orbits which extend our realm of study to the outer Solar System for candidates as extinct or dormant comets.
2. Discovery of dust and volatile comae from 2060 Chiron. Chiron is now known to be a comet.
3. Observational studies of properties of comet nuclei compared to near-Earth asteroids.
4. Studies of individual near-Earth asteroids which are extinct comet candidates.
5. Observations of dust trails associated with short period comets.
6. Discovery of a dust tail on a prediscovery image of 4015 Wilson-Harrington.

2. New Discoveries

Newly discovered objects in the outer Solar System (Figure 1) are logical targets for physical study and comparison with properties of comet nuclei and asteroids. One of these objects, 1991 DA, now named 5335 Damocles, is ~5 km in diameter and is an Earth-approaching object with aphelion beyond Uranus (Steel *et al.* 1992). 5145 Pholus, the outer Solar System object discovered in early 1992 in the course of the Spacewatch Search Program (Scotti *et al.* 1992) crosses the orbits of Saturn, Uranus, and Neptune. These two objects are probably dormant or extinct comets based on their orbital dynamics, though observing efforts to date by Steel *et al.* (1992) for Damocles, and by Hainaut and Smette (1992) for Pholus, revealed no evidence of either dust or gaseous cometary activity. It should be pointed out and we discussed later, that comet-like activity on distant objects is likely to be sporadic. They are far away, relatively small, and thus push the limits of observational techniques, so any one set of negative results is not presently conclusive.

The discovery of more Jupiter-crossing asteroids, for example, 5164 1984 WE_1, provides more candidates with dynamically short life times which might be comets in evolved orbits. Jewitt and Luu (1993a) discovered two distant objects beyond the orbit of Pluto, 1992 QB_1 and 1993 FW which are possibly members of the Kuiper Belt, a postulated source of short-period comets. Four additional objects beyond Neptune were discovered in the fall of 1993 (Luu and Jewitt 1993, Jewitt and Luu 1993b, Williams *et al.* 1993). Future astrometric observations to refine orbits, and photometry to determine their physical properties such as size and color will be directly relevant to understanding the nature of the reservoir of short period comets. The discovered objects both in the outer and inner Solar System increases the available population for the study of the nature of suspected dormant and/or extinct comets.

3. The Discovery of Dust and Volatile Comae from 2060 Chiron

The discovery of cometary activity associated with 2060 Chiron has been pivotal to advancing our understanding of the comet-asteroid transition. Chiron is sometimes active and it is therefore a comet. The story of the discovery of its cometary

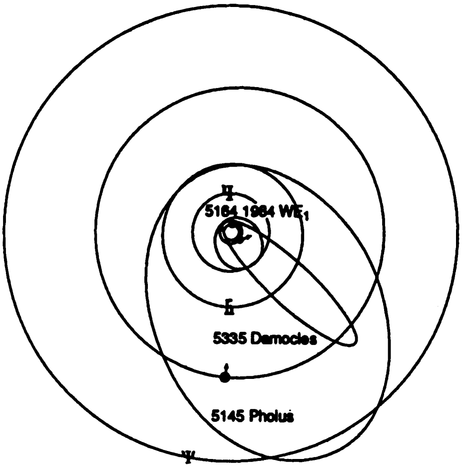

Fig. 1. Plane view of the Solar System with orbits of the planets Earth, Mars, Jupiter, Saturn, Uranus, and Neptune and the recently discovered objects 5145 Pholus, 5335 Damocles, and 5164 1984 WE_1. Their orbits are now or were recently dynamically similar to short-period comets.

activity is illustrative of the interplay of discovery, speculation, and observation, a satisfying example of the process of scientific advancement. Since its discovery in 1977 (Kowal 1979), it was suspected of being a comet. Due to its great distance from Earth, technological limitations of observational instruments and perhaps the limited activity of the comet itself, little was known about it until the wide-spread availability of CCD's in the 1980's. Significant brightness variations as measured with broad-band filters were detected between mid-1987 and 1988 suggesting cometary activity (Hartmann *et al.* 1990). Meech and Belton (1990) first detected a coma in 1989 with CCD imaging. An image of Chiron showing its dust coma is presented in Figure 2. Confirmation of this was reported by Luu and Jewitt (1990a).

A CN emission band was reported by Bus *et al.* (1991) from observations in 1990. Early speculations that Chiron was an inactive comet have now been confirmed by a series of observations. Past brightness variations can be interpreted in terms of cometary activity as Marcialis and Buratti (1993) have recently presented. Buratti and Dunbar (1991) and Luu and Jewitt (1990a) reported short-term impulsive variations. We are now confident because of both independent and repeated observational measurements that Chiron is a comet. Understanding its outbursts and the mechanisms controlling them is the goal of future studies as Chiron comes to perihelion in 1996. The procedure for demonstrating Chiron's cometary nature, detecting both a dust and gas coma can be used to identify other inactive or once dormant comets.

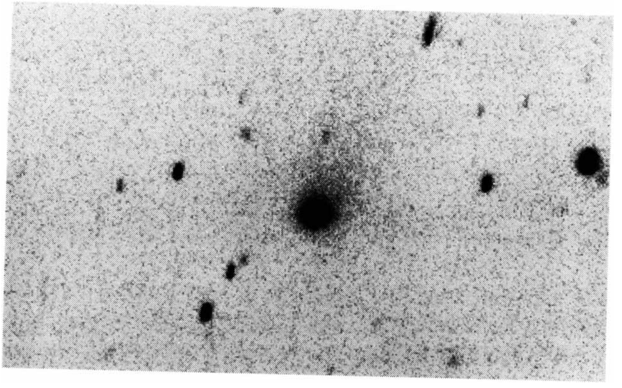

Fig. 2. A CCD image of 2060 Chiron, 1992 January 6, acquired by Karen Meech. The distribution of dust in the coma is asymmetric.

3. 1. SEARCH FOR DUST COMAE AROUND OTHER SMALL BODIES

Luu and Jewitt (1992a) searched for faint dust comae among near-Earth asteroids (NEAs) by comparing surface brightness profiles imaged through the R filter with star profiles. In so doing they were able to put upper limits on the mass loss rates ($\dot{M}$) from eleven NEAs of $\leq$ 0.01-0.30 kg sec^{-1}. The calculated upper limits are model-dependent; particle density was assumed to be $\rho = 1000$ kg/m^3, mean grain size $\bar{a} = 0.5$ μm, and R, radius, was estimated from $M_v(1,1,0)$ assuming an albedo, p = 0.1. $\dot{M}$ is calculated from equation

$$\dot{M}_c = \frac{(1.1 \times 10^{-3})\pi \rho \bar{a} \eta R_{NEA}^2}{dr^{0.5}\Delta}$$

and can be compared with comets as shown in Figure 3. The parameter, η, is the ratio of the coma cross-section to the nucleus cross-section. The angular diameter of the photometry diaphragm, d, is in units of arcsec and r and Δ are in units of AU.

The derived upper limits are 2-4 orders of magnitude less than active comets. This is a significant result as long as the parameters of the above equation are reasonable values. An increase in density or mean grain size of the particles would raise the dust production limit though no excess above the star profile was observed. The results of this approach should be made with similar measurements in which the telescope tracks the asteroid instead of the comparison star. It is worth continuing to make such observations as opportunities arise because dormant comets are most likely sporadically active.

3. 2. SEARCH FOR GAS COMAE

Ground-based and spaceborne instruments have been used to search for OH and CN in some candidate cometary nuclei. Cochran *et al.* (1986) searched for CN with

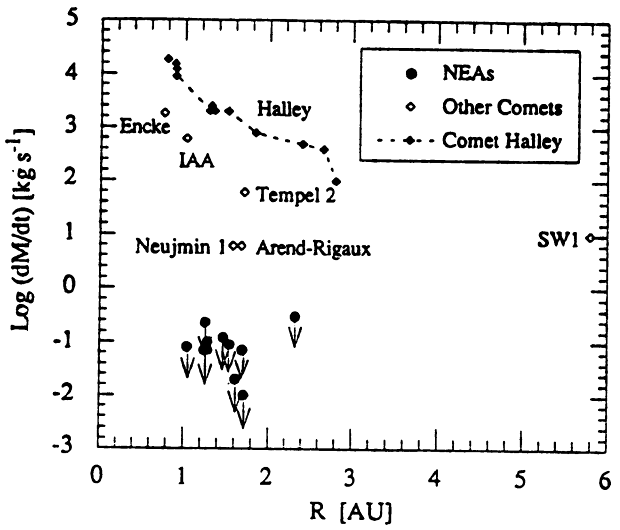

Fig. 3. Derived mass loss rates ($\dot{M}$) for comets and near-Earth asteroids as a function of heliocentric distance (R) from Luu and Jewitt (1992a).

an IDS spectrometer and reported upper limits for a number of cometary candidates. Recent searches for gas comae were presented by Schulz *et al.* (1993) and Chamberlin *et al.* (1993). Three-sigma production rate upper limits were reported for OH at 1566 Icarus, 4015 Wilson-Harrington, and 2201 Oljato (Table I). CN was searched for with a CCD spectrometer from which a 3-σ upper limit was derived for Oljato, and a 2-σ detection was made at 4015 Wilson-Harrington (Table I). That the instrument sensitivities are at the level of the lowest level of measured volatile activity of active comets is particularly frustrating as the results prevent a conclusive difference between volatile activity of comet-candidates among the asteroids and low levels of cometary activity. More sensitive measurements are required.

4. Observations of Comet Nuclei Compared to NEAs

Jewitt (1992) reviewed the physical properties of cometary nuclei in terms of their known rotations, shapes, sizes, and surface reflectance properties. I will describe the general view of comet nuclei, but with the caveat that I am uncomfortable stating their characteristics as representative of all comet nuclei. No one has yet demonstrated that the present distributions are representative of all comet nuclei.

4. 1. SIZES

The six comet nuclei that have been studied directly tend to be small, on order of 2-20 km in effective diameter. But Chiron has a diameter of approximately 300 km (Sykes and Walker 1991, Jewitt and Luu 1992, Campins *et al.* 1992, Campins 1993). Knowing that Chiron is a comet, one cannot accurately say that all comet nuclei are small. I believe we do not yet know the size distribution of comet nuclei.

TABLE I
Upper limits and/or the average of measured gas production rates of selected asteroids and comets

Object	OH (sec^{-1})	CN (sec^{-1})	Reference
2201 Oljato	$\leq$ 2-3 $\times 10^{26}$	$\leq 1 \times 10^{23}$	Schulz *et al.* 1993
1566 Icarus	$\leq 5 \times 10^{25}$		Schulz *et al.* 1993
4015 W.-H.	$\leq$ 2-3 $\times 10^{26}$	1×10^{22}	Chamberlin *et al.* 1993
P/Neujmin 1	7.47×10^{26}	1.66×10^{24}	Campins *et al.* 1987
P/Tempel 2	2.1×10^{27}	3×10^{24}	A'Hearn *et al.* 1989
P/Arend-Rigaux	2.67×10^{26}	1.99×10^{24}	Millis *et al.* 1988

TABLE II
Diameters and albedos of six comet nuclei

Nucleus	D (km)	Albedo	Reference
P/Arend-Rigaux	$26 \times 16 \times 16$	0.03	Millis *et al.* 1988
P/Neujmin 1	17.6-21.2	0.03 ± 0.01	Campins *et al.* 1987
P/Encke	4.4-9.8	0.04	Luu and Jewitt 1990b
P/Halley	$16.0 \times 8.2 \times 8.4$	0.04	Keller *et al.* 1987
P/Tempel 2	5.9×11.8	0.02	A'Hearn *et al.* 1989
2060 Chiron	284 ± 46	0.04 ± 0.03	Campins 1993

4. 2. ROTATION RATE

Belton (1991) thoroughly reviewed the state of the art of determining rotation rates of cometary nuclei. The theory and observations used to determine rotation rates are well-presented in Belton's review, to which I refer anyone who wishes to develop an appreciation for the thought and effort involved in deriving these values and their uncertainties. I suggest that anyone using these values for analysis become familiar with the methods from which the results were derived. These values, as are most physical parameters, are not as certain as reading a number tends to make them appear.

In a study of the rotation rates of NEAs compared to main belt asteroids of similar size range (2-10 km) and to cometary nuclei, Binzel et al. (1992) conclude that the rotation rates of similar-sized main belt asteroids are indistinguishable from the near-Earth asteroids. Thus based on rotation rates alone, the NEAs could have all been derived from the main belt. When one addresses the question of whether or not a contribution from comet nuclei can be distinguished from the NEA population, the measurements of rotation rate of comets are not of uniform reliability and the sample is not of comparable size. Five comet rotation rates were analyzed by Binzel (there are nine now available) compared to 30 measured NEA rotation rates. Using Student's t test, from 0-40% of the NEA population could be made up of a cometary component, assuming that the distribution for the comet nucleus rotation rate and lightcurve amplitude is indeed representative of the comet population. One concludes from this that rotation rate alone is not an adequate discriminator of comets.

4. 3. ALBEDO

The albedos of cometary nuclei studied to date tend to be low, ranging from 0.02-0.04 as currently measured (Jewitt, 1992). We have adopted as reasonable those measurements which have been made on the eight cometary nuclei of low-to-negligible activity and Halley (studied at close range). In the matter of the albedo of Chiron, if one were to believe the albedos derived from the standard thermal model (STM), and/or the isothermal latitude model (ILM), (Campins *et al.* 1992) one would conclude that the albedo of Chiron is higher than any comet nuclei previously measured, with derived albedos of 0.18 and 0.06 respectively. However, when Campins (personal communication, 1993) makes a correction for the contribution of a coma, the resulting albedo is about 0.04. This value seems more likely when one considers the large absorption coefficient of most carbon-bearing materials. If all comets contain some carbonaceous material, it is not surprising that all comet nuclei would be dark. Assuming that our assumptions of the chemical compositions of comets are correct, and that our models from which albedos are derived are reasonable, then the generalization that comet nuclei are dark is reasonable, and maybe even accurate. As a discriminator of a member of the short period comet reservoir, versus the asteroids, a low albedo is not diagnostic. Approximately 60% of all asteroids have albedos of a few percent. So as a signature of an extinct comet, albedo alone is not valid.

4. 4. SPECTRAL REFLECTANCE

Spectral reflectance measurements of NEAs covering 0.4-2.5 μm which contain absorption bands that are diagnostic of mineralogical composition have been obtained by Vilas and McFadden (1992), Bell *et al.* (1988), and Cruikshank *et al.* (1991). If an asteroid or cometary nucleus candidate has a reflectance spectrum with a UV absorption band edge and a 2- and/or 1-μm band with a moderate to high albedo, the surface composition consists predominantly of mafic silicates and the object is most likely derived from the inner edge of the main asteroid belt and is not a remnant of a comet. An asteroid that was once considered a possible comet nucleus by Kresàk (1979), 1866 Sisyphus, can no longer be considered so because its reflectance spectrum as reported in Vilas and McFadden (1992, Figure 4) has the characteristic of an S-type asteroid and is probably derived from the inner asteroid belt. The other two NEAs in Figure 4, 433 Eros and 1036 Ganymed, are the two largest NEAs. Their reflectance spectra also indicate that they most likely were perturbed from the inner main belt based on the spectral criteria mentioned above.

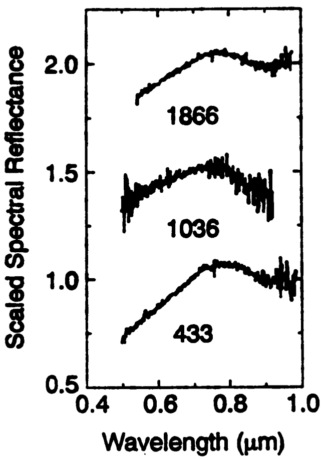

Fig. 4. CCD Spectral reflectance of near-Earth asteroids 1866 Sisyphus, 1036 Ganymed, and 433 Eros from Vilas and McFadden (1992).

Luu (1993) presents spectral reflectance between 0.38-0.7 μm taken with a long-slit CCD spectrometer of both comet nuclei and extinct comet nucleus candidates among the near-Earth asteroids. It is unfortunate that this spectral region contains little information about common rock-forming minerals, no absorption bands down to the instrumental wavelength resolution of 10 Å FWHM, and a wide range of photometric uncertainty (from 5-50%) . In the absence of compositional information, Luu reduces her data to a single parameter called normalized reflectivity gradient S'_λ, expressed in % per 0.1 μm, where positive values imply a reddened spectrum compared to that of the sun,

$$S'_\lambda(\lambda_1, \lambda_2) = (dS/d\lambda) \Big/ S_\lambda$$

$$\lambda = 0.5\mu m$$

The results are a diversity of values from the highest of 46.1 for 5145 Pholus, to a negative value -3 for 2060 Chiron. The negative slope parameter of 2060 Chiron is a significant exception to the reddening trend that Vilas and Smith (1985) and Hartmann *et al.* (1987) and others believe holds throughout the tremendous distances in the Solar System.

5. Observations of Individual Near-Earth Asteroid, Extinct Comet Candidates

Coordinated observing campaigns and analysis of physical studies of single objects across all available observational wavelengths is another approach to investigating the subject of the comet-asteroid transition. An example of this type of investigation is the study of 2201 Oljato (McFadden *et al.* 1993). Our current conceptualization of Oljato as originating from the asteroid or comet reservoir remains uncertain. If it is an extinct comet, we don't know it because it is not clear what the physical properties of an extinct comet are. Currently, we can't be sure that an object is extinct without prior evidence of cometary activity.

Schulz *et al.* (1993) report upper limits for OH at Oljato from the International Ultraviolet Explorer (IUE) satellite. Oljato is an unusual asteroid. Whether or not it is an extinct or dormant comet, or unusual because of another physical reason, not certain at this time.

6. Dust Trails Associated with Short Period Comets

Dust trails first observed by IRAS and reported by Sykes *et al.* (1986) and Sykes and Walker (1992) consist of large refractory particles (sub-millimeter-sized) ejected at low velocities (on order of m/sec) and have presently been associated only with short period comets. Figure 5 is an illustrative schematic including a comet dust trail.

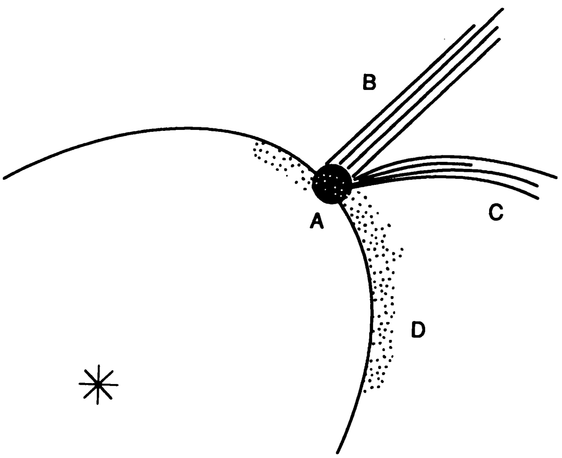

Fig. 5. A schematic drawing of the components of a comet including A) Coma B) Ion tail C) Dust tail and D) Dust trail from Sykes and Walker (1992).

If this association proves unique, that is if no dust trails are associated with asteroids, then the large particle dust trails could be a signature of extinct comet nuclei. In fact, if they are signatures of comets the dust trails will contain a record of the past $10^1 - 10^2$ years of cometary activity of dormant or extinct comets. Though the opinion has been expressed that this is not sufficient time to make dust trails a significant indicator of cometary activity, this may be considered an advantage or a disadvantage. True, there would be no record of cometary activity from thousands of years ago or more, on the other hand, the opportunity to collect information on

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a scale of centuries is significant compared to the length of an individual's scientific career. It is important to investigate the possibility of the association of dust trails with asteroids to obtain constraints on formation mechanisms of dust trails.

7. Discovery of Dust Tail on Prediscovery Image of 4015 1979 VA

In my opinion the most significant advance in our understanding of the comet-asteroid transition in the past few years is Ted Bowell's discovery of the prediscovery images of 4015 1979VA on the first Palomar Sky Survey prints (Bowell 1992). On plates taken 1949 Nov. 19.1 UT, B.A. Skiff found a slightly fanned tail 2.8' in length on the blue print at position angle $90° \pm 5°$, the antisunward direction is 76° (Figure 6).

This plate is sensitive to dust tail emissions, whereas the red plate is not sensitive to scattered light from dust. Brian Marsden noted that the 1949 object is comet P/Wilson-Harrington 1949g=1949 III. Reports from the 1949 apparition indicate that the comet was asteroidal in appearance on subsequent Palomar Schmidt exposures through Nov. 25, 1949.

It is important to review the observational data constraining the physical properties of 1979VA, now known as 4015 Wilson-Harrington. My summary is derived from a 1980 presentation (Degewij *et al.* 1980) entitled "1979 VA : Physical Parameters of a Possible Cometary Nucleus." The argument presented at the time, that 1979 VA was a cometary nucleus, was not then persuasive. The evidence available now is.

7. 1. SIZE

During the 1979 apparition, no infrared measurements of this asteroid were obtained from which size information could be derived using the standard radiometric model. Harris and Young estimated a diameter of ~3 km by assuming a low albedo, an assumption made from its UBV colors of B-V=0.66 ± 0.02 and U-B=0.31 ± 0.02. Campins *et al.* (1993) acquired simultaneous visible and near-infrared measurements from the 1992 apparition, deriving a diameter of 2.6-3.8 km.

7. 2. ROTATION RATE

Harris and Young (1983) report a photometric lightcurve, P~4 hours, amplitude=0.06 from two nights' data. In their paper, they note that they have four nights of data but that the photometric quality of the observations was poor and warranted being discarded. Upon the linkage of this asteroid with the periodic comet observed in 1949, Harris checked his data again and reaffirmed that the data quality were poor and that he discarded them for the correct reason, not because he wasn't expecting cometary activity.

7. 3. TAXONOMY

From three nights' observing, Tholen and Tedesco acquired 8-color photometry. Tholen classified it a CF according to his minimal tree cluster analysis (Tholen 1984). It is interesting to note that Tholen speculated that the color represented in *u* and *b* filters of the eight-color system might result from a contribution of CN emission which falls in the bandpass of these two filters.

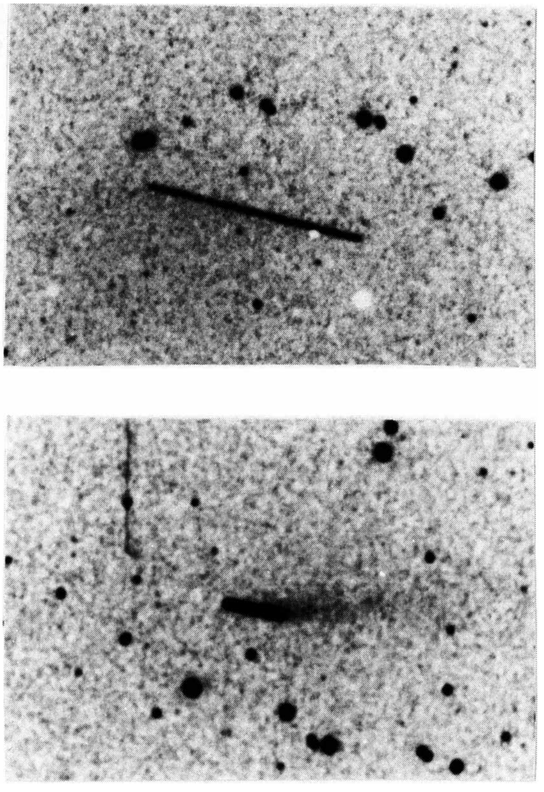

Fig. 6. TOP - Palomar Sky Survey print of 4015 Wilson-Harrington Nov.19.1 1949 UT on red photographic emulsion, 45-min exposure. A very faint tail is reported but not obvious on the print. BOTTOM - Blue emulsion 15-min exposure showing the dust tail with peak apparent brightness of 23 mag/square arcsec.

7.4. ALBEDO

There is no measured albedo from the 1979 apparition. It was always inferred to be low based on the UBV colors and Tholen's taxonomy. Campins *et al.* (1993) derive a J bandpass albedo ranging from 0.02-0.10, depending on the model used. The use of isothermal latitude model, from which the lower albedo is derived, is probably more appropriate to the physical conditions at Wilson-Harrington.

7.5. SPECTRAL REFLECTANCE

Spinrad and Stauffer (Degewij *et al.* 1980) have one night of data covering ~0.4-0.7 μm (Figure 7). Their spectrum combined with Tholen's eight-color asteroid survey data show a UV absorption edge and a flat reflectance (to within 10%) out to 1.6

μm. This type of spectrum is more similar to spectra of C-type asteroids than any of the other comet nuclei observed. Of the observed comet nuclei, they either are quite red (greater than 10% change in reflectance over the observed wavelengths) or don't have much of a UV absorption (e.g. Weissman *et al.* 1989).

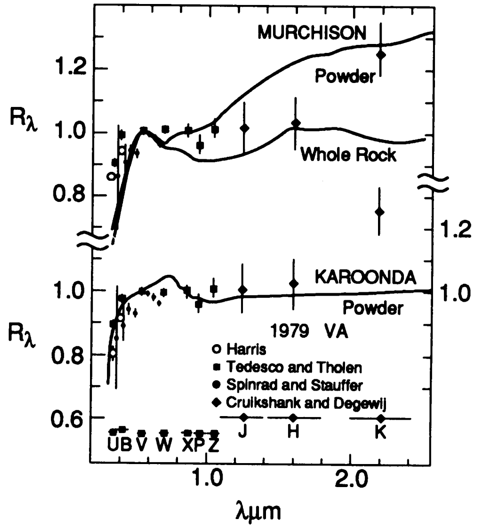

Fig. 7. Spectral reflectance measurements from 1979 apparition of 4015 Wilson-Harrington.

Hartmann *et al.* (1982) obtained JHK and near-simultaneous optical photometry. H-K is high, 0.27 (Figure 8), which fall in a region of color space near J6 (the jovian moon, Himalia). Chiron is not too far away on the V-J, J-K plot. Only comet Slaughter-Burnham, an active comet, has a higher H-K value than 1979 VA, although including the 0.1 mag uncertainty, this high color difference may not be significant. Nevertheless, the region in the near-IR between 1 and 2 μm in comets may be an important region to study and understand better. It is not clear what the physical significance of this result is. Campins *et al.* (1993) did not observe the same phenomenon.

Gaffey provided an interpretation of the available spectra from 1979 (Figure 7) considering possibilities in terms of meteoritic analogues (Degewij *et al.* 1980). His interpretation is of a surface with a moderate iron abundance in a mafic silicate with abundant opaques. The closest similar meteorite type is an evolved (thermally metamorphosed) carbonaceous chondrite, called Karoonda; it is a C4. One can now ask if interpreting the spectrum in terms of meteoritic analogues is appropriate? Doing so is valid, whether or not the interpretation holds must be demonstrated. The red H-K color, which is measured on two different days, is not consistent with the C4 meteoritic analogue.

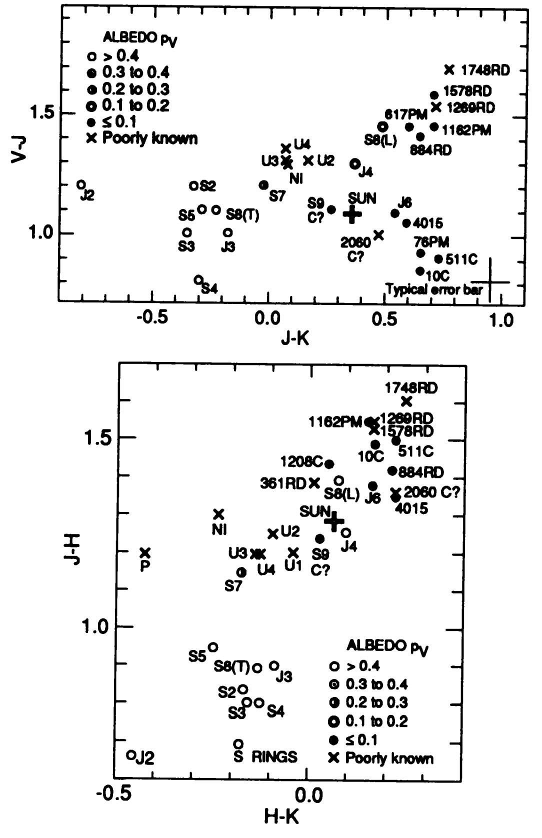

Fig. 8. Near-infrared color plots showing 4015 Wilson-Harrington, some asteroids, comets, and satellites of outer planets.

8. Summary

In summary, active search programs are producing new discoveries of small Solar System bodies. Studying the physical and dynamical properties of these objects will lead us to a better understanding of the composition of the comet and asteroid reservoirs and of the processes by which they evolve into their current orbits.

2060 Chiron, which was referred to as a distant asteroid five years ago, is now known to be a comet. This knowledge provides a new perspective on the dynamical evolution of small bodies and perhaps on our definition of a comet. The discoveries of a dust and gas coma are the first verification of the hypothesized phenomenon of a dormant comet, demonstrating the existence of remnant or sporadic cometary activity. The next step is to characterize the physical properties of those objects known to be dormant or inactive comets with subsequent observations and modelling.

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The numerous studies investigating the distribution of physical properties of the nucleus of comets compared to the population of near-Earth asteroids represent a necessary step in the investigation of the comet-asteroid transition. We need to increase the available measurements of the physical properties of comet nuclei, a tremendous amount of work, requiring careful data collection and analysis. At the same time, theoretical studies explaining any significant statistical findings in physical terms ar e required. An example of such work is that of Prialnik and Mekler (1991), in which they model the formation of a dense ice crust below the surface of a comet nucleus as a function of time for comet Halley. Similar studies for objects on different orbits and with different sizes and albedo would be useful.

Efforts directed at studying the physical properties of extinct-comet nucleus candidates have not yet been successful in determining the signature of an inactive object that initially derived from the short period comet reservoir. I have suggested that dust trails from comets might be an indicator of comets, though this matter is currently speculative and may not provide evidence of a cometary origin if trails are also associated with asteroids. It is possible to use existing Infrared Astronomical Satellite (IRAS) data to look for evidence of dust trails associated with asteroids. Success in the effort to find a diagnostic signature of extinct or dormant comets will come from studying those objects known to be dormant and sporadically active. Searches for more dormant comets will contribute to the effort. The association of asteroid 1979 VA with periodic comet P/Wilson-Harrington 1949 III brings the number of known dormant comets to two, Chiron with its sporadic activity, being the other.

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