Chapter 8

The Nuclei of Comets Wild 2 and Utsunomiya

8.1 Background

These are the two comets for which I have the least amount of data, so I will discuss both in one chapter. Much of the text I have already presented elsewhere (Fernández *et al.* 1999a).

81P/Wild 2 is the target of the *Stardust* mission, which is currently en route. If successful, the spacecraft will collect grains from the comet's dust coma by trapping them with an aerogel, and return them to Earth. An interesting factoid about the comet itself is that it was perturbed into its present orbit only in 1974, when it passed less than 12 Jovian-radii – within Ganymede's orbit – from the gas giant's cloud tops. Before that, the comet lived almost totally in the outer planetary region, with a perihelion slightly within Jupiter's orbit and aphelion around Uranus' orbit and beyond. Thus, among the short-period population, this is likely one of the least processed objects, having spent so little time within 5 AU of the Sun.

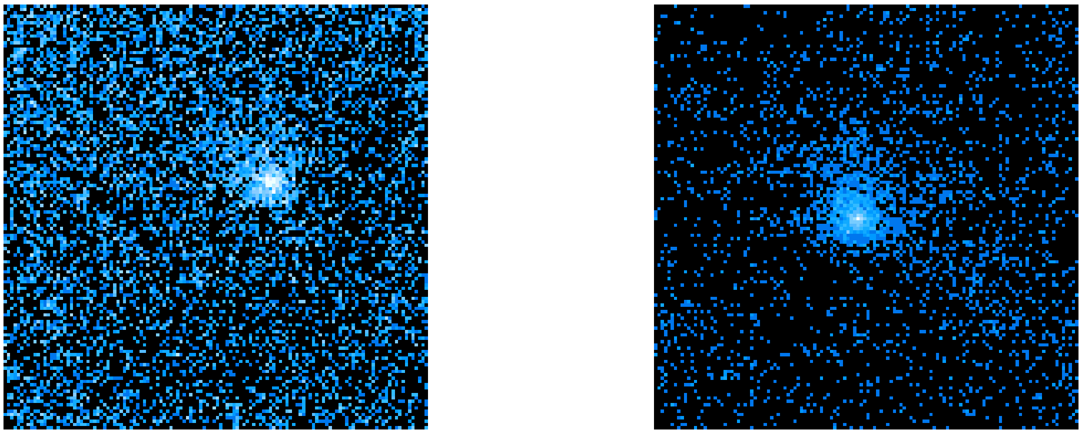
Comet Utsunomiya 1997 T1 was discovered at 11th magnitude by an amateur. This comet is old in the Oort sense, having an original semimajor axis of 862 AU (Marsden and Williams 1999). It is one of many run-of-the-mill long period comets that we must eventually sample in great numbers.

8.2 Utsunomiya

On 23.9 Nov 1997 we imaged Utsunomiya at NASA/IRTF with the MIRAC infrared camera. At the time, $r = 1.38$ AU, $\Delta = 1.65$ AU, and $\alpha = 36.6°$.

The comet had a flux of 0.6 ± 0.1 Jy at 10.6 μm and is shown in Fig. 8.1a as the median of 13 images. It was slightly extended, apparently not a point-source. In Fig. 8.2 I show a model coma which, when subtracted from the image, leaves hardly any point-source remaining: about 10% of the flux. However this does *not* mean the dust coma dominated the signal, since the centroiding and adding of the 13 images together was tricky due to the low S/N per pixel. It is entirely possible that the "dust coma" is spurious because of incorrect registering of the image centroids.

Strictly speaking, we can only calculate an upper limit to the effective radius. Assuming all of the flux is nuclear, I assign the usual ranges for the parameters of the STM and find an effective radius $R_{\rm N} = 5.8 \pm 2.0$ km, $T_{SS} = 350$ to 370 K, and $T_B = 275$ to 315 K. To our knowledge this is the only infrared data on this comet and



a b

Figure 8.1: Mid-infrared images of comets Utsunomiya and Wild 2. On the left (a) is an image of comet Utsunomiya at a wavelength of 10.6 μm, and on the right (b) is comet P/Wild 2 at 11.7 μm. The comets are extended sources but it is unclear whether this is due to real dust comae or just a consequence of the tricky registering of multiple images of a faint comet.

the only estimate of its nuclear size. Unfortunately we have access to neither nuclear magnitudes of this comet nor deep images, so we cannot yet estimate p. Also, the rotation period is unknown, so there is no rotational context for this measurement. If the nucleus were a rapid rotator and if the rotation axis were perpendicular to the Sun-comet-Earth plane at the time of observation, the effective radius would be higher, about 9 ± 2 km.

8.3 P/Wild 2

On 29.3 Jan 1997 we imaged Wild 2 at NASA/IRTF with the MIRAC infrared camera. A the time, $r = 1.85$ AU, $\Delta = 0.87$ AU, and $\alpha = 5.9°$.

The comet had a flux of 0.5 ± 0.1 Jy at 11.7 μm and is shown in Fig. 8.1b as the median of 53 images. It too was slightly extended, apparently not a point-source, however the S/N per pixel was even lower than for Utsunomiya. In Fig. 8.3 I show a model coma which, when subtracted from the image, leaves hardly any point-source remaining: less than 10% of the flux. I am less confident of the reality of the "dust coma" for this comet than for Utsunomiya.

Hence again we can only calculate an upper limit to the effective radius. Assuming all of the flux is nuclear, and again assuming the usual range of parameters for the STM, I find $R_{\rm N} = 3.0 \pm 0.6$ km, $T_{SS} = 300$ to 320 K, and $T_B = 265$ to 285 K. We were unable to acquire any rotational information, so we cannot tell how much variation there is in the cross section. However Meech and Newburn (1999) report that time series of optical flux while the comet was at high heliocentric distances do not show much rotational signature at all; i.e., there is a good chance that the comet is close to spherical. So the lack of rotational context for our mid-IR measurement may not be a problem.

Meech and Newburn (1999) have also derived the nucleus' optical cross section: $pR_{\rm N}^2 = 0.165 \pm 0.014$ km^2. With our derived value of $R_{\rm N}$, we calculate p to be 0.018 ± 0.005 (formal error), lower than the canonical value. An overestimation of the nuclear IR flux due to coma contamination might explain the low albedo. However there are comets with comparably low values (see Chapter 9).

If the nucleus were a rapid rotator, it would have to be close to spherical and the radius based on my mid-IR data would be about 6.5 ± 1 km. Moreover the albedo would then be even lower than quoted above.

8.4 Summary of This Chapter

Comets Utsunomiya and P/Wild 2 were briefly imaged in the mid-IR from the Infared Telescope Facility in Hawaii. The former comet has a maximum effective radius of 5.8 ± 2.0 km if the STM is valid, or about 10 km if it is instead a rapid rotator. No companion optical data are available, and the rotation state is unknown.

The latter comet is the target of a spacecraft and thus is a more popular object for study. Our mid-IR data imply a radius of 3.0 ± 0.6 km if the STM is valid. Optical data (Meech and Newburn 1999) imply that the nucleus is either spherical or has a very long (on order of days) rotation period. The albedo is apparently very low, about 2%, but it is possible that there is some coma contamination in the thermal data.

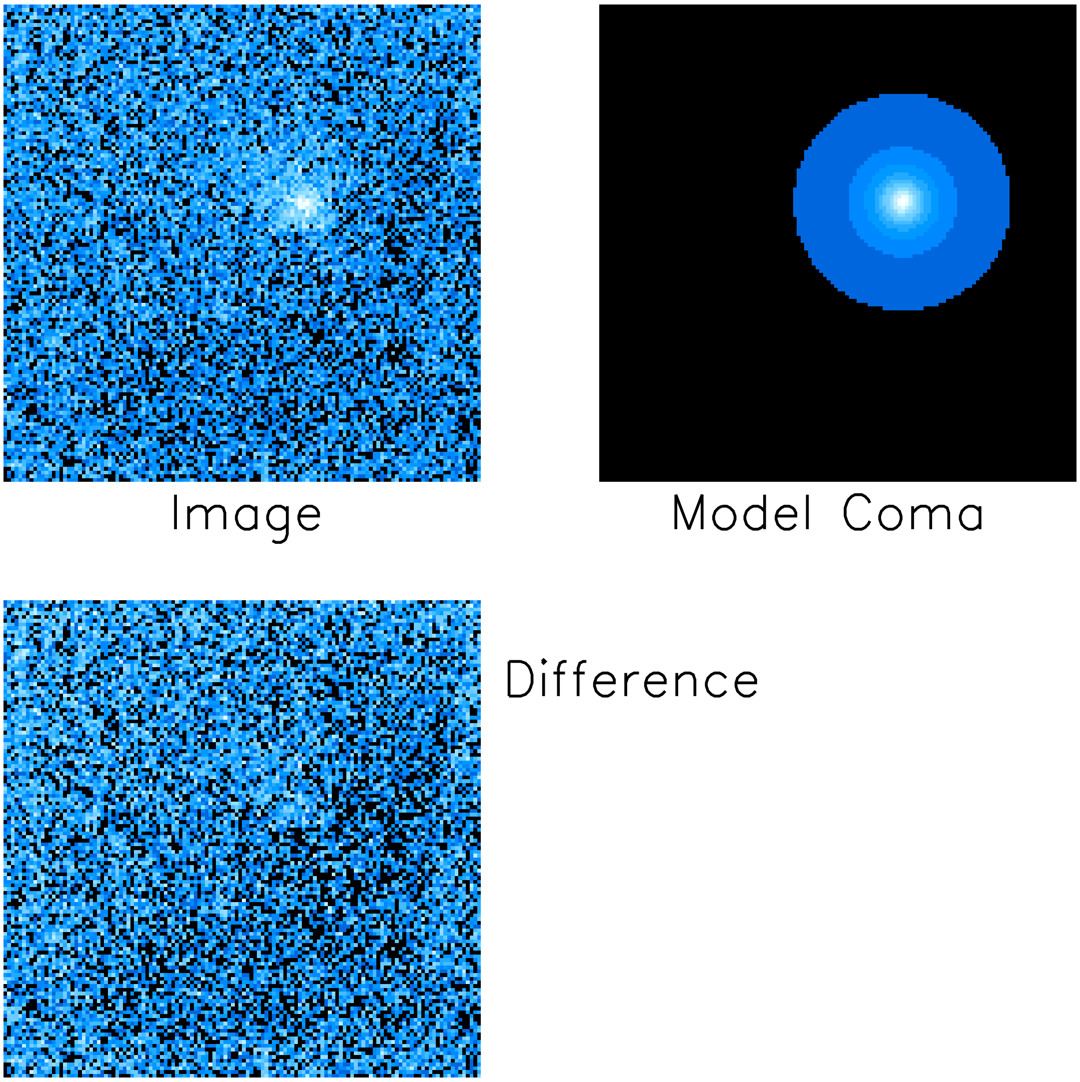


Figure 8.2: Coma-fitting method applied to comet Utsunomiya. Here I show the results of the coma-fitting method after application to comet Utsunomiya's mid-IR image. Virtually all of the flux can be modeled as comatic, since there is very little flux left in the difference image, but since the individual images of the comet were difficult to centroid properly, this may be just an error in pixel registering.

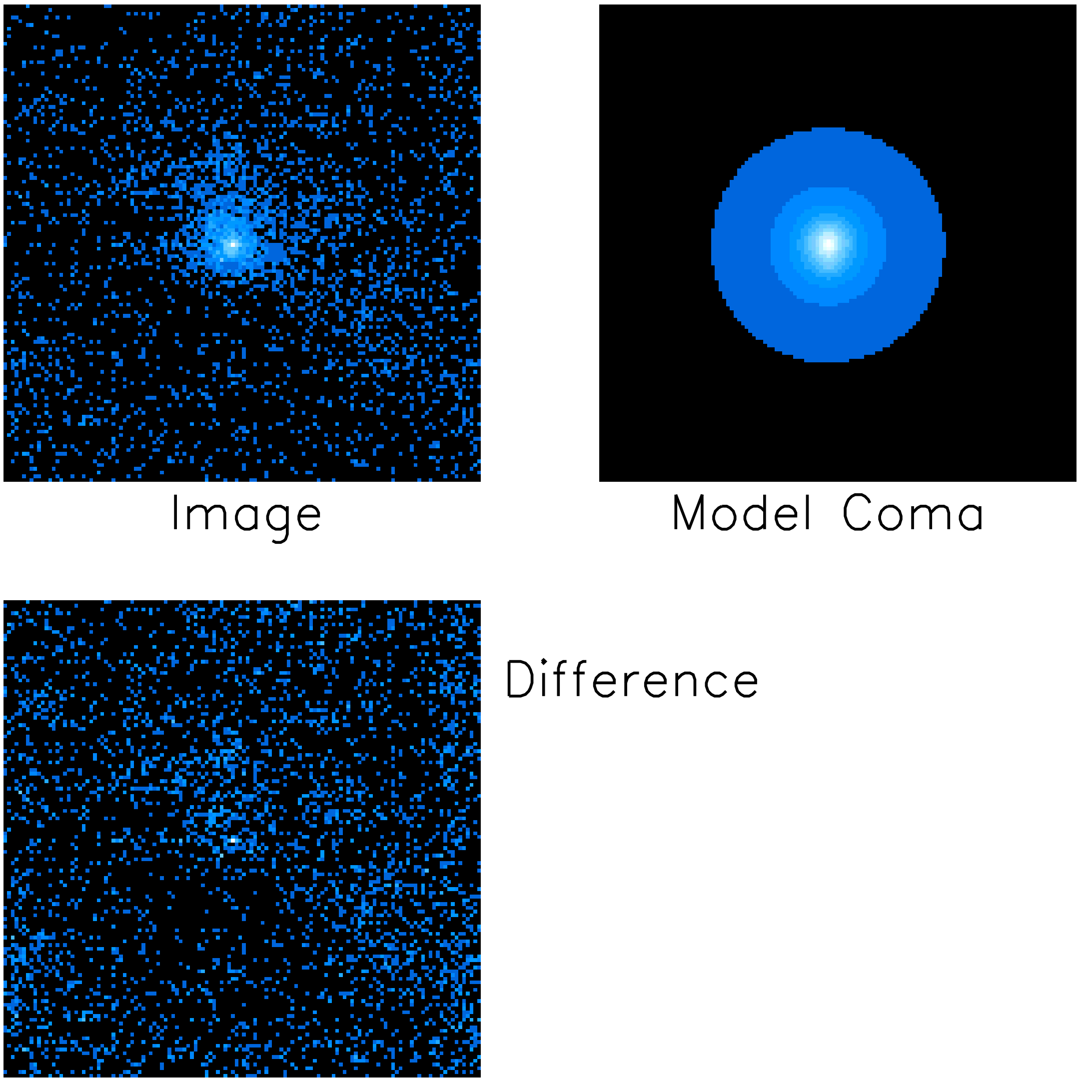


Figure 8.3: Coma-fitting method applied to comet P/Wild 2. Here I show the results of the coma-fitting method after application to the mid-IR image of comet P/Wild 2. Virtually all of the flux can be modeled as comatic, since there is very little flux left in the difference image, but since the individual images of the comet were difficult to centroid properly, this may be just an error in pixel registering.