The active asteroids

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Active asteroids simultaneously possess the orbits of main-belt asteroids and the physical appearances of comets; they show transient dust comae and solar-radiation pressure-swept tails. Apart from the shear surprise at finding such strange objects in the asteroid belt, the active asteroids are scientifically interesting for several reasons. Although we are limited to scarcely more than a dozen examples, the active asteroids already reveal the distinct action of different physical processes, each previously unobserved and carrying big-picture importance for understanding the solar system.

1. IMPACT. An unambiguous asteroid-asteroid impact was observed in 2010, when a 30-m scale body struck 100-km diameter (596) Scheila. Direct observations of impacts hold scientific importance both by sampling this natural process at full scale (compared with laboratory impacts conducted at tiny scales) and because impact statistics will allow us to assess the erosion rate in the asteroid belt and the contribution of asteroid dust to the interplanetary medium.

2. CRITICAL ROTATION. Several objects have been observed in which the best explanation seems to lie with spin-up to critical periods, presumably (but not certainly) caused by YORP. Examples of both likely mass-shedding (P/2010 A2, P/2013 P5) and full break-up (P/2013 R3, shown below) exist. It has been suggested that, at sub-kilometer sizes, spin-up disruption rates may surpass impact disruption rates. Future observations will show whether or not this is true, and may ultimately lead to an improved understanding of the physics of break-up.

3. THERMAL DISINTEGRATION. Geminid parent (3200) Phaethon shows on-going mass-loss at perihelion, driven by the 1000-K surface temperatures found there. The mechanisms appear to be some combination of thermal fracture and desiccation stress.

4. SUBLIMATION. Two objects have shown repeated activity that appears to be correlated with position in the orbit. The best example is 133P, which has been observed to re-activate at four consecutive perihelia. Such repetition indicates the action of a thermal trigger, the simplest example of which is the sublimation of near-surface water ice. The scientific significance arises because the outer asteroid belt is a likely source region for terrestrial planet volatiles, including some fraction of the Earth's oceans. Some asteroids may preserve samples of ice formed at much smaller distances (and higher temperatures) than Kuiper-belt and Oort-cloud comets.

5. UNKNOWN. In a majority of active asteroids, the driving mechanism cannot yet be unambiguously identified as a result of inadequate observations. This is good news for future work, which we hope will reveal even more unexpected phenomena and perhaps the action of processes currently beyond our imagination.

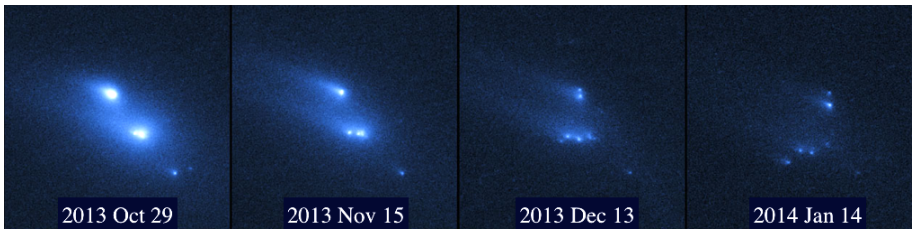

Figure: Active Asteroid P/2013 R3