Topics: Moons and rings of outer planets, asteroids, TNOs, comets

Reading:

- Review from the middle of p. 252 to the end of Ch. 10 (moon and rings), but do *not* worry about the previous two pages, about magnetic fields.
- Read sec. 3 of Ch. 4 in Ryden and Peterson (pp. 92 - 97, *Limits On the Sizes of Orbits*; this is relevant especially for the giant-planets'-moons-and-rings sections of Ch. 10). You can back a few more pages before those and read about tides, if you'd like, though we discussed the most relevant parts in class a few weeks ago (recall that tidal forces go like $1/r^3$).
- Read the first three sections of Ch. 11 in Ryden and Peterson (pp. 267 - 280).

Summary of work to submit:

- Nothing to submit for Tuesday's class, for now, though I may send one short problem a few days ahead of time (see the very end of this document).

Overview:

The smaller (than planet-sized) objects in the Solar System are very important, too: they have a remarkable diversity of properties, they in some sense are "left-overs" from the formation of the Solar System and so hold a lot of clues about how the Solar System formed, they interact with planets in interesting ways, and they sometimes crash into the Earth (and other objects).

Commentary on the reading, viewing, and other preparation:

The information at the beginning of §10.2.2 about how/why objects are spherical versus irregular shaped is interesting and broadly relevant (including for the definition of planets). Note that it depends on the material properties of the planet/moon/asteroid/whatever (Table 10.1) but basically is due to self-gravity – if it's strong enough – pulling an object into the most compact shape possible.

Our Moon is really quite exceptional (and "giant") – see Table 10.2. Think about how its existence actually *is* consistent with the nebular hypothesis of Solar System formation (even though the main part of the theory anticipates giant moons only around Jovian planets).

And those moons are expected because Jovian planets are big enough to pull in surrounding gas due to their gravity and that accreting gas is bound to have too much angular momentum to accrete directly and so must form an orbiting disk. So...giant planet moon formation is very much like a miniature Solar System formation scenario. Do you see how the differences in the properties of the four Galilean satellites of Jupiter confirm this scenario?

What are the consequences of Titan's conditions being close to the triple point of methane? Can you imagine some exotic form of life living on Titan?

Interesting mystery about Uranus vs. Neptune's temperature (p. 258).

Rings: here is where you will want to go back to Ch. 4 and read about the Hill radius and Roche limit (relevant for planetary moons, too). Do you think Saturn's rings are likely to be a gravity-crushed former moon? What dictates how shiny vs. dark (high vs. low albedo) ring particles (and comets, etc.) are? Also...shepherd satellites! I prefer to think of them as sheep dogs...

Ch. 11 – asteroids – here again the phenomenon of orbital resonances comes up. There are complexities, but resonances tend to clear out bodies when they are much, much less massive than the thing they're in resonance with (e.g. Kirkwood gaps) but can lock objects into an orbit when the masses are more nearly equal (e.g. Jupiter's moons).

The concept of Lagrange points is interesting. Recently, NASA has started to put satellites into orbit around the Earth-Sun and Earth-Moon Lagrange points (for various reasons, having satellite telescopes not too close to the Earth is good).

§11.2 – note the role of orbital interactions and resonances here too. "Scattering" in this context means a close gravitational encounter that seriously alters the orbit of the smaller object. Study Fig. 11.5 carefully (as well as the text describing it, of course). Do you see how close encounters with Neptune strongly affect the properties of objects in the outer Solar System?

Now that you know about the history of the discovery of Ceres and other asteroids and also the properties of Eris, Pluto, and Makemake, does the "demotion" of Pluto from planet status seem sensible to you?

Also, the textbook was written before the flyby of Pluto and Charon by the New Horizons spacecraft which produced some amazing images, like the one below. If you're motivated, check APOD or NASA websites for other images of Pluto.

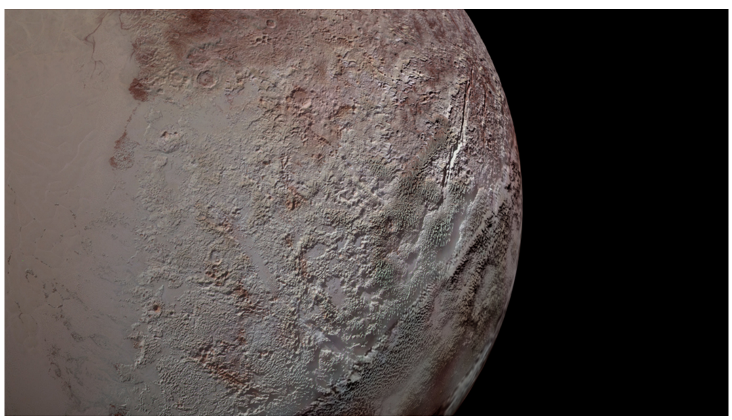

Fig. 1 Pluto as imaged by NASA *New Horizons* spacecraft in 2015 – https://apod.nasa.gov/apod/ap171005.html

§11.3 – the Oort cloud and Kuiper belt are full of objects! Our popular conception of comets streaking across the night sky represents only a tiny fraction of comets. Note also how the concepts of volatiles and solar irradiance temperature leads to the formation of comet tails when they get an appropriate distance from the Sun.

Comets have two tails (one gas, one dust). The dust one is blown off the comet by radiation pressure from sunlight (we'll talk about radiation pressure in class).

...I may send you a short pre-class problem to do in order to prime our discussion of radiation pressure (and radiation force).