Honors Seminar 292 — cheat sheet for 9/30/2019 — Andrew Baker

Stevenson (2001)

You should read the whole article. Key questions:

1. What are the two lines of evidence the author presents to argue that the solar system and the Jovian satellites did *not* form in the same way? In what respect is the formation of the Earth-Moon system again different?

2. Are the Jovian satellites that we see now likely to have been the only ones ever formed?

Key terms:

- **accretion** = process by which a large mass builds up through the slow addition of smaller particles or masses
- **accumulation time** = length of time it takes for a solid body to build up to a given mass from a gas structure (e.g., a disk)
- **angular momentum** = roughly speaking, the product of the mass, distance, and velocity of one object orbiting another (or of an object spinning about its own axis); this is a quantity that is *conserved* (i.e., remains constant) unless one applies a *torque* to the system
- **collapse time** = length of time it takes for a gas cloud to collapse into a condensed structure (e.g., a disk)
- **differentiation** = the extent to which the various consitutents of a mixture (e.g., the rock and ice constituting a planetary satellite) have separated from each other
- **heat of vaporization** = energy per unit mass required to convert a substance into a vapor
- **migration** = process by which one body revolving around another moves to a different orbital radius due to gravitational interactions with other orbiting material
- **orbital time** = length of time it takes for one body to revolve around another
- **prograde** = adjective describing orbital motion that is in a "right hand" sense (as described by the direction your right hand's fingers curl when your right hand's thumb is pointing up)

Canup & Ward (2006)

For this paper, you should read only the first page and the last paragraph ("General implications"); you may also find Figures 2, 3, and 4 interesting. Key questions:

1. What are the differences between the "regular" and "irregular" satellites of the outer planets?

2. Why do the authors claim that they can characterize the amount of gas in a circumplanetary disk as a "quasi-steady state"?

3. If we detect an extrasolar planet of a given mass, what can we conclude about the mass(es) of any satellite(s) in orbit about it, according to the authors of this paper?

Key terms:

- **aerodynamically bound** = tied together via frictional forces
- **aerodynamic drag** = a generalization of air resistance to the friction exerted by any fluid
- **analytical** = in this context, describes a pencil-and-paper calcluation rather than a simulation done with a computer
- **order of magnitude** = factor of ten

ALMA Partnership et al. (2015)

For this paper, you should read the abstract; the first, second, and fifth paragraphs of section 1; sections 3.1.2 and 3.1.3; and sections 4 and 5. Key questions:

1. What tyoe of material is responsible for the emission that is detected from the HL Tau system?

2. What is the significance of the bright and dark rings seen in Figure 2?

3. What arguments do the authors make in favor of the argument that the bright and dark rings are associated with planets?

Key terms:

- **^{13}CO** = carbon monoxide moleculae in which the most common isotope of carbon (with six neutrons) has been replaced with a heavier isotope of carbon (with seven neutrons)
- **AU** = astronomical unit, which is the distance between the Earth and the Sun
- **azimuthally averaged** = for a disk-like structure, a calculation in which all points at the same radial distance from the center are averaged together
- **Band 6+7** = sum of data observed with ALMA receivers operating at two different frequencies (233.0 and 343.5 GHz, respectively)
- **bolometric** = adjective describing the total (summed over all wavelengths) radiation produced by an astronomical source
- **brightness temperature** = T_B = a quantity describing the apparent brightness of an object at radio wavelengths

- **Class I–II protostar** = young star at an early (but not the earliest possible) stage of its evolution
- **column density** = total amount of gas or dust projected along our line of sight
- **disk kinematics** = motions of gas inside a disk
- **dust continuum** = emission from interstellar dust grains that arises over a wide range (i.e., "continuum") of dust grains
- **dust opacity spectral index** = grain emissivity index (see below)
- **eccentricity** = value between 0 and 1 indicating how non-circular a given ellipse is
- **flux density** = observed energy per unit time per unit area per unit frequency from an astronomical source
- **free-free** = adjective describing radiation from an ionized plasma due to the acceleration of free electrons as the pass by free positive ions
- **Gaussian** = mathematical function describing a smooth, symmetric peak
- **grain emissivity index** = β = parameter used to describe the spectrum of dust continuum emission; typically has a value between 1 and 2
- **image fidelity** = degree of consistency between an astronomical image of a source and what the source actually looks like in reality
- **inclination** = angle describing the tilt of a disk relative to our line of sight, which can range from 0° (face-on) to 90° (edge-on)
- **interferometric** = adjective describing an observation made with an array of telescopes
- **James Clerk Maxwell Telescope** = telescope located on Maunakea in Hawaii specializing in observations at submillimeter wavelengths
- **Keplerian motion** = orbital motion in which the object being orbited is much more massive than the object doing the orbiting, as in the case of dust grains in orbit around a star
- $L_\odot$ = total luminosity of the Sun ($3.9 \times 10^{33}\,\mathrm{erg\,s^{-1}}$)
- **LSR** = local standard of rest, which is an idealized reference frame describing the mean revolution of the Sun and solar system around the center of the Milky Way
- $M_\odot$ = total mass of the Sun ($2.0 \times 10^{33}\,\mathrm{g}$)
- **mag** = abbreviation for "magnitude," a logarithmic quantity describing how bright an object is, or how much fainter it appears to be as a result of interstellar dust along the line of sight

- **mas** = milliarcsecond, i.e., one thousandth of one 3600th of a degree (a very small angle!)
- **Markov Chain Monte Carlo** = type of computer algorithm capable of determining the uncertainties in the parameters of a model
- **mean motion resonance** = MMR = orbital resonance (see below)
- **optical depth** = τ = measure of whether a medium is transparent ($\tau < 1$) or opaque ($\tau \gg 1$) to radiation
- **optically thick** = material that is not at all transparent, and cannot be seen through
- **optically thin** = material that is transparent
- **orbital resonance** = relationship between the orbits of two bodies orbiting a third, in which the ratio of the orbital periods is a ratio of small integers
- **PdBI** = Plateau de Bure Interferometer, an array of radio telescopes in France
- **phase stability** = steadiness of the atmosphere at the time of an astronomical observation; higher phase stability is better
- **position angle** = angle describing the orientation on the sky of an elongated (or apparently elongated) structure; 0, 90, 180, and 270 degrees correspond to north, west, south, and east
- **proper motion** = apparent motion of a star or other astronomical object across the sky, from the point of view of the Earth
- **reflection nebula** = cloud of gas that we are only able to observe because it is reflecting light in our direction from a deeply embedded source (e.g., young star)
- **Science Verification** = category of observation made early in the commissioning of a new telescope, in which a previously studied source is observed to confirm that the new telescope is working
- **SED** = spectral energy distribution, which describes how much light an object produces as a function of wavelength
- **spectral index** = α = exponent in a function $f_\nu \propto \nu^\alpha$ describing the spectrum of an astronomical source
- **synthesized beam** = effective angular resolution of an image produced with an array of radio telescopes
- **very long baseline interferometry** = observational technique involving the combination of data from widely separated telescopes in order to achieve spectacularly high angular resolution (i.e., sharpness) in an image

- **visual extinction** = amount (expressed in magnitudes, and represented as A_V) by which an astronomical source has been obscured by interstellar dust at optical wavelengths