Companion Frequency and Mass Ratio Distribution of M Dwarfs Project

[For N. Susemiehl by Prof. Meyer Winter Semester 2018]

You should plan to spend at least 3 hours per week working on this project on average, over the whole term (or 14 x 3 = 42 hours total). This can include meetings with a research supervisor once every two weeks for 30-50 minutes. Specific meetings where you present results to the group in depth or in the Star, Planet, and Formation group meeting can also count. The outcome will be a poster presented at the Undergraduate Research Poster Session in April as well as a short report. You should use python notebooks to carry-out the calculations.

Based on the available surveys for companions to M dwarfs, both radial velocity, microlensing, astrometry (?), and direct imaging, compare the derived companion frequency. This should be done over a fixed range of q, the ratio of the companion mass to the primary mass, relative to a “global frequency” which is over the q range [0.1, 1.0] and integrated over all separations. The assumed functional form for the companion mass ratio distribution should be taken from Reggiani & Meyer (2013): dN/dq ~ q^{-beta} or N = integral { dN} = integral {dN/dq} dq

The surface density of companions as a function of semi-major axis should be taken to a log-normal in a: dN/dloga = constant exp{[log-a - <log-a>]/sigma-log-a^2}

where the “mean-log-a” is the log of 5.3 AU and sigma-log-a can be derived from sigma-log-P = 1.3 using Kepler’s Law (Duschene & Kraus, ARAA 2013) compared to FGK stars (Raghavan et al. 2010) with mean-log-P corresponding to P ~ 450 yrs (a ~ 45 AU) and sigma-log-P = 2.3. The total multiplicity frequency can be estimated:

N/N\_total = integral (dN) = double-integral { dn/dlog-a x dn/dq} dloga dq

Tasks:

1. Do a literature search and identify a set of multiplicity studies for M dwarf host stars that are complete or representative over a well-defined range of orbital separation (semi-major axis a) and companion mass ratio (q).
2. Check whether the observed companion mass ratio distributions from all samples are consistent with each other using the KS test.
3. Fit a model to these point estimates of the companion frequency over each range of q and a to estimate the total frequency of companions over q = [0.1, 1.0] and a = [0,infinity]. Is this result consistent with the same frequency for FGK stars estimated by Raghavan et al. (2010)? Extrapolate this frequency to q = [0,1.0] for M and FGK stars.

Finally, check whether there is any evidence that the companion mass ratio distribution depends on orbital separation within any sample.