ABSTRACT on Presentation

Hypervelocity Stars and Planets

(based on 14 Mar 2012 Astro-ph.GA Paper "*Hypervelocity Planets and Transits Around Hypervelocity Stars,*" by Idan Ginsburg, Abraham Loeb & Gary A. Wegner)

Jeffrey Binckes

Introduction: At the center (at the location of the star SgrA*) of our Milky Way Galaxy lies a massive black hole with a mass of ~4 x 10^6 solar masses. When a binary star system approaches this massive black hole, the system can be tidally disrupted. This disruption can lead to the ejection of one of two binary stars from the Milky Way at velocities of (on average) ~1500 km/sec. The other star loses energy and falls into the gravitational well and remains in orbit around the black hole. Such events that kick stars out of their normal orbits have been dubbed "hypervelocity stars" (HVSs). The subject study also shows that, in much the same manner that HVSs are ejected, planets can reach similar and even significantly higher velocities (1.5 to 4.0 times faster than their HVS counterparts). Such events are called, as might be expected, "hypervelocity planets," (HVPs)!

Computational Methods: The study of three or more bodies under mutual gravitational attractions, as we have studied in class, has no analytical solution to the equations of motion, and thus requires the use of computer numerical simulations. The authors employed a *N*-body code written by Aarseth (1999, PASP) which uses a direct *N*-body integrator where each particle is followed with its own integrations step. This study ran around 10,000 simulations of stars and planets in orbit around the massive black hole. The authors slightly varied the distance, ***A****, between the binary stars as well as their orientation—in order to minimize any bias in their results. Next to each star, the simulation model placed one or two planets, nominally at a constant distance, ***Ap***; however, later simulations varied the planetary separation distance as well.

Results: The simulations show that in order to produce as HVS with planets in orbit, the initial binary separation needs to be in the range ***A**** = 0.05 – 0.5 AU; and, the planetary separation in the range ***Ap*** = 0.02 – 0.05 AU. For such scenarios there is up to a ~10% probability that a HVS is produced with orbiting planets. In such scenarios there is also a significant probability that at least one planet transits the star.

Added Value; re: J.Binckes: What really intrigues me is when the binary star system is disrupted by the black hole what is the relationship between the energy *lost b*y the star which falls into the gravitational well and remains in orbit around the black hole; versus, the energy *picked up* by the star which is kicked out of the binary system and escapes the gravity of the black hole (in some cases ejected out of the Milky Way galaxy). I will attempt to show the ejected star's increase in velocity/energy equals the energy lost by the black hole captured star. In other words, the *energy of the pair is conserved*.