

Theoretical Partner-Swapping in Triple Star Systems

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Theoretical orbit-swapping in multiple star systems has been discussed previously by various authors, it is not intended here to list all previous works, a good example can be found at [1].

In a hierarchical triple star system, two of the stars orbit around each other forming a binary pair (this is usually called the inner orbit). The other star is a single star. The single star, and the binary pair, orbit around each other (and this is usually called the outer orbit).

If both orbits are on the same plane, then there are two distinct types of hierarchical triple star system. Prograde systems (both orbits are in the same direction) and retrograde systems (the inner and outer orbits are in opposite directions).

Retrograde triple star systems are in general much more stable than prograde. Prograde triple star systems are fine if the inner orbit and the outer orbit have reasonably different sizes, but if the two orbits are similar in size, they are unstable. And this instability can be interesting, because in some cases, the stars may repeatedly swap partners.

Here an HTML5 simulation [2] is presented which shows a theoretical partner-swapping system in motion. This is a live numerical integration.

In the simulation, the red and orange stars initially are the binary pair, and the yellow star is the single star. But soon the yellow star sneaks in and lures the red star away into an extra-orbital affair, leaving the orange star alone. A sequence of many partner-swaps follows. All three stars have turns at being the single star, and turns at being tied up in a couple. Eventually, after many partner-swaps, the red star disappears from view, alone. The orange and yellow stars, happily entwined, disappear together in the opposite direction, and the *ménage-à-trois* is over.

The star system shown in the simulation presented here is one of the 141 hypothetical three-body systems examined and illustrated by Chen & Lin in [3], and uses starting parameters they give in [4].

Many further partner-swapping triple-star systems may be generated by creating coplanar triple star systems which are prograde (outer orbit is in same direction as inner orbit) and in which the size of the inner orbit is similar to the size of the outer orbit.

References

[1] Hurley, J. R., Shara, M. M.
The Promiscuous Nature of Stars in Clusters
arxiv.org/abs/astro-ph/0201217

[2] Edgeworth, S.
HTML5 orbit simulation
www.orbsi.uk/space/simulator/simulator.php?s=00039

[3] Chen, K. C., & Lin, Y. C.
On action-minimizing retrograde and prograde orbits of the three-body problem.
Communications in Mathematical Physics, 291(2), 403-441.
www.math.cts.nthu.edu.tw
See specifically the first system illustrated in the top row of figure 21.

[4] Chen, K. C., & Lin, Y. C.
www.math.nthu.edu.tw/~kchen/papers/retr-prog-initial-data.txt
See specifically the first system in the prograde orbits section.

Version history

v2: updated link to java animation.

v3: 02 Dec 2017 removed java simulation, added HTML5 simulation, and rewrote text to match.