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Approximate action-angle variables for the figure-eight and other periodic three-body orbits

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(Submitted on 17 Jun 2011)

We use the maximally permutation symmetric set of three-body coordinates, that consist of the "hyper-radius"  $R = \left[\left\{\frac{rho}{2} + \frac{ambda}{2}\right]\right]$ , the "rescaled area of the triangle"  $\left[\frac{sqrt 3}{2} - \frac{rho}{2}\right]\right]$   $R^2 \left[\left\{\frac{bm rho}{times} \left\{\frac{bm rho}{ambda}\right\}\right]\right]$  and the (braiding) hyper-angle  $\left[\frac{sqrt arctan}{rac{2}{bm}} - \frac{rho}{2}\right]\right]$ , to analyze the "figure-eight" choreographic threebody motion discovered by Moore  $\left[\frac{Moore1993}{10}\right]$  in the Newtonian three-body problem. Here  $\left[\frac{bm rho}{tmo}\right]$ ,  $\left[\frac{bm rho}{3}\right]$  are the two Jacobi relative coordinate vectors. We show that the periodicity of this motion is closely related to the braiding hyper-angle  $\left[\frac{spris}{10}\right]$ . We construct an approximate integral of motion  $\left[\frac{bar{G}}{3}\right]$  that together with the hyper-angle  $\left[\frac{spris}{10}\right]$  forms the actionangle pair of variables for this problem and show that it is the underlying cause of figure-eight motion's stability. We construct figure-eight orbits in two other attractive permutation-symmetric threebody potentials. We compare the figure-eight orbits in these three potentials and discuss their generic features, as well as their differences. We apply these variables to two new periodic, but nonchoreographic orbits: One has a continuously rising  $\left[\frac{spris}{stab}\right]$  in time t, just like the figure-eight motion, but with a different, more complex periodicity, whereas the other one has an oscillating  $\left[\frac{spris}{stab}\right]$ 

Comments:11 pages, 19 figuresSubjects:Mathematical Physics (math-ph); Classical Physics (physics.class-ph)Journal reference:Phys Rev E83, 056603 (2011)DOI:10.1103/PhysRevE.83.056603Cite as:arXiv:1106.3413 [math-ph](or arXiv:1106.3413v1 [math-ph] for this version)

# Submission history

From: Veljko Dmitrasinovic [view email] [v1] Fri, 17 Jun 2011 08:34:18 GMT (419kb)

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