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Title: *"New linkage methods for large databases of optical observations"*

Abstract. With the rapid increase of asteroid detections, the identification of asteroids from observations taken in different nights requires more efficient algorithms. For this problem we consider very short arcs (VSAs) of asteroid observations. A VSA is usually not enough to compute an orbit; however, by linear or quadratic interpolation, we can compute an attributable at the mean epoch of the observations, that is a vector whose components are the topocentric angular position and velocity of the asteroid. An orbit is defined by the attributable and the topocentric radial distance and radial velocity of the observed body at that epoch.

The linkage problem consists of computing one or more preliminary orbits by using the information contained in two attributables. One possible way to solve this problem is to impose that the integrals of the motion take the same value at the two epochs of the attributables. An alternative procedure is the classical orbit determination method by Gauss, which uses three angular positions of the asteroid, typically belonging to three different VSAs. In this case the preliminary orbits are computed by solving a polynomial equation of degree 8.

With modern telescopes the number N of observations per night is very large. Using Gauss' method for the identification problem we have to solve $O(N^3)$ polynomial equations. A linkage algorithm, instead, have to be applied $O(N^2)$ times. Therefore, if we could find a polynomial equation for the linkage with low degree, we would significantly decrease the computational complexity of the problem.

We present the results reported in Gronchi et al. (2015) on the use of the two-body integrals to compute preliminary orbits by linking VSAs of observations of celestial bodies. In this work, by combining the algebraic integrals of the two-body problem we find a univariate polynomial of degree 9 in the radial distance of the orbit at the mean epoch of one of the two arcs. Following Gronchi et al. (2017), we show that the degree 9 is optimal in some sense.

Then, we describe a linkage method to join together three VSAs (Gronchi et al. 2017): from the conservation of the angular momentum it is possible to obtain a polynomial equation of degree 8 at the mean epoch of the second VSA.

We conclude with some numerical tests on the performance of the new methods and show that they can also be used when the time separation between the VSAs is large.

Joint work with Giovanni Federico Gronchi, Stefano Marò, Andrea Milani Comparetti.

References

[1] Gronchi, Baù, Marò, CMDA 123(2), 105–122 (2015).

[2] Gronchi, Baù, Milani, CMDA 127(2), 211–232 (2017).