Kozai Mechanism Vs GR Precession in Daytime Arietids (ARI)

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The Daytime Arietids (IAU #0171 ARI) are one of the strongest known meteor showers (Jenniskens 2006) on Earth in the list of daylight showers (Campbell-Brown 2004). The ARI meteoroid stream is known to show long term General Relativistic (GR) precession (Sekhar 2013, 2014) due to its low perihelion distance. In addition, the orbital elements of the ARI stream are such that a large proportion of ARI particles undergo Kozai libration (Sekhar et al. 2017a) during its long term evolution (Sekhar et al. 2016, Vaubaillon et al. 2019).

We find that in a purely Newtonian simulation, due to the active Kozai mechanism (Sekhar et al. 2017b), certain sub-structures in the ARI stream can eventually fall into the sun and thereby deplete certain parts of the stream. However, when we include the GR precession effect in the simulation, we see that those particles which had sun-colliding trajectories (due to Kozai mechanism) no longer have sun-colliding paths for an extended time. Switching on the GR precession in most cases either delays the sun colliding time frame or changes the long term evolution in such a way that the particles miss the sun.

It is therefore shown that indirectly GR precession helps in preserving and preventing certain sub-structures in the ARI stream from falling into the sun. Calculations to demonstrate this significant change in orbital evolution were done using analytical as well as numerical methods. Analytical calculations were done using a Hamiltonian dynamics formulation (Morbidelli 2011) by employing separate Hamiltonians for both Kozai cases and GR+Kozai cases. Numerical simulations were done using numerical integrations by both excluding and including the GR precession routines.

We consistently find that GR+Kozai cases increase the survival times of certain sub-structures in ARI stream in our theoretical simulations. In the future, it would be even more insightful if we could correlate this effect with real observational data (Campbell-Brown 2004). The aim will be to find observational records (Sekhar 2018) for certain ARI sub-structures (which are depleted due to Kozai and sun-colliding fate in the Newtonian-only model) hitting the Earth due to the change in evolution induced by GR precession, thereby demonstrating an exact identification of this phenomenon in real observations. Moreover if we can map the narrow orbital phase space (Asher et al. 1999) in the stream which gets dramatically altered due to GR precession and subsequently pinpoint the real meteors on Earth emanating from that phase space (i.e. sub-structures which have avoided falling into the sun within their evolutionary time frame specifically because of the GR effect), it will be an elegant separate confirmation of General Theory of Relativity (Einstein 1915) at work in meteor science.

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