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Change in General Relativistic precession rates due to Lidov-Kozai oscillations in the Solar System

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Introduction: Two well known phenomena associated with low perihelion distance bodies in orbital dynamics are general relativistic (GR) precession and Lidov-Kozai (LK) oscillations.

The accurate prediction of the perihelion shift of Mercury in accord with real observations is one of the significant triumphs of the general theory of relativity developed by Einstein. The Lidov-Kozai mechanism was first proposed and derived by Kozai and independently by Lidov explaining the periodic exchange between eccentricities e and inclinations i thereby increasing or decreasing the perihelion distance q secularly in the orbiting body.

Co-existence of GR Precession and LK Oscillations: In this work, we were interested to identify bodies evolving in the near future (i.e. thousands of years in this case) into rapid sungrazing and sun colliding phases and undergoing inclination flips, due to LK oscillations and being GR active at the same time. Of all the bodies we checked from the IAU-Minor Planet Center, and Marsden plus Kracht families from the comet catalogue, 96P/Machholz 1 stands out because it shows all these trends in the near future.

LK leads to secular lowering of q which in turn leads to a huge increase in GR precession of argument of pericentre. This in turn gives feedback to the LK mechanism as the e, i and argument of pericentre in Kozai cycles are closely correlated. In this work, we find real examples of solar system bodies which show the continuum nature between GR precession domi-nant and LK mechanism dominant regimes.

Results and Discussion: We have shown that there are bodies in the solar system in which both GR precession and LK mechanism can co-exist at the same time and for which these effects can be measured and identified using analytical and numerical techniques. Thus there is a continuum of bodies encompassing, firstly GR precession dominant, secondly GR precession plus LK mechanism co-existing and finally LK mechanism dominant states which are all permissible in nature.

A real solar system body in this intermediate state is identified using compiled observational records from IAU-Minor Planet Center, Cometary Catalogue, IAU-Meteor Data Center and performing analytical plus numerical tests on them. This intermediate state brings up the interesting possibility of drastic changes in GR precession rates (at some points peaking to about 60 times that of Mercury's GR precession) during orbital evolution due to sungrazing and sun colliding phases induced by the LK mechanism, thus combining both these important effects in a unique and dynamically interesting way. Comet 96P/Machholz 1 stands out as the only real body identified (from our simulations) to be exhibiting these interesting traits, as well as inclination flips, in the near future. Both these phenomena complimenting and co-existing at the same time has interesting implications in the long term impact studies of small bodies in general.