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The Geological Orrery: Mapping Chaos in the Solar System from Geology on Earth

Due to gravitational interactions the Solar System is chaotic and precise solutions for the motions of the planets are limited to about 60 million years in the past and future. A fundamental problem related to the stability of the Solar System is determining how planetary motions have changed over longer timescales. By using a network of coring experiments and outcrops we call the Geological Orrery, named after the 18th and 19th century mechanical planetaria, we are able to recover precise and accurate values for the secular frequencies of the precession of the perihelion of the inner planets from the record of orbitally-paced climate change from tropical lake sediments dating from 223 to 199 million years ago, thus circumventing the limitations of Solar System chaos. A high-latitude climate record is needed to establish corresponding secular frequencies for precession of the orbital planes of the planets and determine the state of gravitational resonances. Future extension of the Geological Orrery continuously from 60 million years ago to beyond the horizon of our present work would allow for a much more complete determination of the gravitational system of the planets and provide an entirely new empirical realm to constrain models of Solar System evolution, further test General Relativity and its alternatives, limit the existence of additional planets in the past, and test redictions of galactic disk dark matter interactions with the Solar System