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Secular resonances in the Solar System and paleoclimate sedimentary records

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The motion of the planets in the Solar System is chaotic (Laskar, 1989, 1990). This chaotic behavior is due to multiple secular resonances in the precessing motion of the orbits of the planets. The main effect of this chaotic behavior is to induce an exponential divergence of nearby orbits that multiplies by 10 the initial error in the model or parameters every 10 Myr. Moreover, due to the interactions of the asteroids which have a chaotic motion on an ever shorter time scale, the possibility of prediction of the precise motion of the planets is strictly limited to 60 Myr (Laskar *et al*, 2011).

On the opposite, a precise solution has been derived for the planetary motion over more than 50 Myr (Laskar *et al*, 2011) that is used for paleoclimate reconstructions. Over time scale that exceed the horizon of predictability of 60 Myr, one can nevertheless use some of the most regular features of the orbital solution, as the 405 kyr in the eccentricity of the Earth (Laskar *et al*, 2004) as a clock for the establishment of geological time scale over the whole Mesozoic era. Once the timescale is established, a major challenge is the geological reconstruction of some features that could constraint the orbital solution.

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