MULTISCALE ANALYSIS OF THE INSTANTANEOUS ECCENTRICITY OSCILLATIONS OF THE PLANETS OF THE SOLAR SYSTEM FROM 13.000 BC TO 17.000 AD[1]

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The high-resolution Jet Propulsion Laboratory DE431 and DE432 planetary ephemeris are used to evaluate the instantaneous eccentricity functions of the orbits of the planets of the solar system from 13.000 BC to 17.000 AD at different time scales. Spectral analyses are performed to determine the frequencies and the amplitudes of the detected perturbations from 0.1-year to 10.000-year periods. Taken as contiguous pairs (Mercury-Venus, Earth-Mars, Jupiter-Saturn, and Uranus-Neptune), we found anti-phase patterns between contiguous planets at specific time scales (30.000 years): namely, the eccentricity of one planet increases while the other decreases. Venus and Earth instead appear in phase. However, on shorter time scales the phase coupling becomes more complex and irregular. Yet, Jupiter and Saturn present a $\pi/2$ phase coupling at the 1000-year scale. Periodogram analysis of the planetary eccentricity functions shows several fast fluctuations whose magnitudes indicate the strength of their mutual interactions where the Jovian planets significantly perturb the orbits of the inner planets. Besides, the wavelet power spectrum and wavelet squared coherence spectrum analyses are adopted to examine the relationships in time-frequency space between the eccentricity functions of each couple of terrestrial and Jovian planets. The analysis reveals the complexity and the evolution of the gravitational couplings perturbing each other planetary orbits. In some cases and for specific frequencies, this analysis technique also led to the discovery that the coherence phase can rotate clockwise or anticlockwise. The eccentricity function of the orbit of Jupiter presents large oscillations with periods of about 60 and 900–960 years, mostly due to the interaction with Saturn. These oscillations also correspond to oscillations found in several geophysical records. The eccentricity functions of Uranus and Neptune are characterized by a large 4.300-year oscillation. The eccentricity function of Pluto is characterized by a large nearly 20.000-year modulation.

Keywords: Eccentricity function, Orbital perturbations, Planetary system.

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