Magic Angle Chaotic Precession

Bernd Binder
Quanics, Salem, Germany
binder@quanics.com

This paper explores the properties of a precessing rotor or a coupled system of precessing rotors (gyroscopes), where a special chaotic behavior in the precession angle can be found if the change of rotor angular velocity is linearly coupled by (an) holonomy to the precession angular velocity and angle. The linear coupling provides for rolling cone paths and allows spinning up and controlling the rotor simply by forcing precession at special quantum magic precession angles. The geometric phase induced by the curved path of the rotor or external curvature and part of the coupling increases with precession angle. This leads to bifurcations in coupling strength resulting in chaotic precession. As an alternative to the *SO*(3) matrix or quaternion representation the treatment of the three coupled rotations is here based on Euler's dynamical equations. First, the classical Magic Angle Precession (MAP) dynamics is realized by a geometric or mechanical condition (type I, transcendental solutions), where it can be experimentally demonstrated how MAP can "slave" angular degrees of freedom allowing the external control of high-frequent spin by slow oscillations. MAP is found in a commercial fitness device and is conceptually approached via Chua's electric circuit. Second, the quantum-gravitational MAP (type II, rational solutions) with discrete precession angles is analyzed on a deeper level requiring intrinsic curvature/relativistic effects adjusting holonomy to quantum numbers. Third, a macroscopic network of MAP elements is presented as a discrete-time recurrent neural network synchronizing to one common MAP I/II dynamics under special pairing and symmetry conditions (type III). In all three cases MAP can be treated as a time-discrete chaotic system with singularities given by the cosine map with several possible links to interesting applications on all scales.

Keywords: Chaotic precession, Spin-orbit coupling, Gyroscope, Magic Angle, Euler's Equations, *SO*(3), Bifurcation, neural net, Chua, Berry, Hannay.