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How the Chandler Wobble is excited by rapid variations in the angular momentum of the fluid Earth (Augustus Love Medal Lecture)

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Earth's polar motion is dominated by a forced annual wobble and by motion with a period of 14 months. The latter motion, called the Chandler Wobble in honor of its discoverer, is at the period of the Eulerian free wobble once wobble-induced defor¬mation and other geophysical effects are included using approaches pioneered by Augustus Love. The apparent Chandler Q is in the range 50 – 1000. If this apparent Q represents physical dissipation, the Eulerian free wobble would be damped out within a century or two. In contrast, the amplitude of the Chandler Wobble is con¬stantly changing with increases and decreases in amplitude by a factor of two observed in less than a decade. Forcing with a mechanism capable of exciting amplitude variations on these short time scales is required. The forcing that excites the Chandler wobble lies between two extremes: impulsive forcing in the spectral domain near the Chandler frequency and impulsive forcing in the time domain. The former is the well-known resonant excitation that, neglecting dissipation, excites the Chandler Wobble gradually, with an increase in amplitude proportional to time. In contrast, impulsive forcing in the time domain excites the Chandler Wobble instantaneously. Nearly instantaneous excitation also takes place for continuous forcing when the forcing varies on a time scale much shorter than the Chandler period. The observed variations in Chandler amplitude on time scales much shorter than the damping time suggest that the rapid and irregular variations in the angular momentum of the fluid Earth are the main mechanism of the Chandler excitation. Resonance cannot generate instantaneous excitation; forcing in the spec¬tral domain outside the Chandler band plays an important role. Considering the forcing in the time domain is not only convenient, but also provides deeper insight into the variation of the Chandler amplitude.

We derive polar motion equations that are both clearer in revealing the physics and more robust to rapid changes in forcing than are the familiar Liouville equations. Because both the polar motion and the variation in atmospheric angular momentum (AAM) are well determined since 1980, we test our theory by calculating the polar motion, 1980 – 2006, driven by the daily variations in AAM after removing the com¬ponent of the AAM at the Chandler period. The calculated increases and decreases in the amplitude of the Chandler Wobble on sub-decadal time scales are reproduced satisfactorily. Thus we demonstrate both theoretically and computationally that ex¬citation of the Chandler Wobble by forcing outside the Chandler band is important.