This had an interesting historical impact on Richard Feynman[3].

> "I was in the cafeteria and some guy, fooling around, throws a plate in the air. As the plate went up in the air I saw it wobble, and I noticed the red medallion of Cornell on the plate going around. It was pretty obvious to me that the medallion went around faster than the wobbling. I had nothing to do, so I start figuring out the motion of the rotating plate. I discovered that when the angle is very slight, the medallion rotates twice as fast as the wobble rate—two to one. It came out of a complicated equation! I went on to work out equations for wobbles. Then I thought about how the electron orbits start to move in relativity. Then there's the Dirac equation in electrodynamics. And then quantum electrodynamics. And before I knew it . . . the whole business that I got the Nobel prize for came from that piddling around with the wobbling plate."

E.g. Free Precession of Earth The earth is a slightly oblate spheroid, $I_s/I \approx 1.00327$. The axis of rotation of the earth is inclined by $\alpha \approx 0.2'' = 0.97 \times 10^{-6}$ rad to the symmetry axis.

We then have $\Omega = 0.00327\omega$.

We know that $\omega = 2\pi/(1\,day)$ so the period of the precession of the the earth's axis of rotation about the pole is predicted to be $2\pi/\Omega = 305$ days. In fact the observed value is 440 days, attributed to the fact that the Earth is not a perfect oblate spheroid, and that is is not a rigid object.

The wobble of the Earth's body axis is $\dot{\phi} = 1.00327\omega$ yielding a period of 0.997 days.

7 Mr. Euler, Meet Mr. Lagrange

7.1 Free Rotation of a General Rigid Body

Consider the $O123$ coordinate system in which the inertia tensor is diagonal. Then

$$T = \sum_1^3 I_i \omega_i^2 \qquad V = constant \tag{150}$$

In Chapter 10 we used $L = T - V$ for the Lagrangian. In this chapter L represents angular momentum, so I will use $\Lambda = T - V$. In the torque free case, the Lagrangian $\Lambda = T$. Let's

[3]Feynman R P 1985 Surely You Are Joking, Mr. Feynman! (New York: W W Norton) see pp 157—158 for a discussion of the rotating plate motion