$$\frac{de}{dt} = -nA_1\beta \sin\phi \tag{2b}$$

$$\frac{d\tilde{\omega}}{dt} = -\frac{nA_2\beta}{e}\cos\phi. \tag{2c}$$

Here t is time, β (always positive) measures the appropriate resonance strength and the A_i are constants. The quantity β is a complicated function of the semimajor axis ratio which must be expanded as a power series; across the small distance over which the resonance exerts its influence, however, β can be treated as a constant. In the gravitational case, β is first order in the satellite/planet mass ratio and $A_1 = A_2 = 1$. In the Lorentz case, β depends on the particle's charge-to-mass ratio, distance from the planet, and the magnetic field strength. For first-order electromagnetic resonances, $A_1 = A_2 = n/n' - 1$, so the 2:1 resonance, like gravity, has $A_1 = A_2 \approx 1$. The dominant contribution to this resonance comes from the g_{32} component of the magnetic field (a non-symmetric octupole term - see /2/ which gives values for the giant planets).

Although we have specialized equations (2a-c) to the 2:1 eccentricity resonance, the form of the equations for other first-order eccentricity resonances (2:3, 3:4, 1:2 etc.) is entirely similar - only the parameters β and the A_i need to be changed. First-order inclination resonances (which exist for Lorentz forces but not for satellite gravity) and higher-order resonances are also not too different. Accordingly, the general behavior discussed below for the 2:1 eccentricity resonance actually applies to a wide variety of other types of resonances as well; that is to say, the trapping and jumps discussed below are general phenomena.

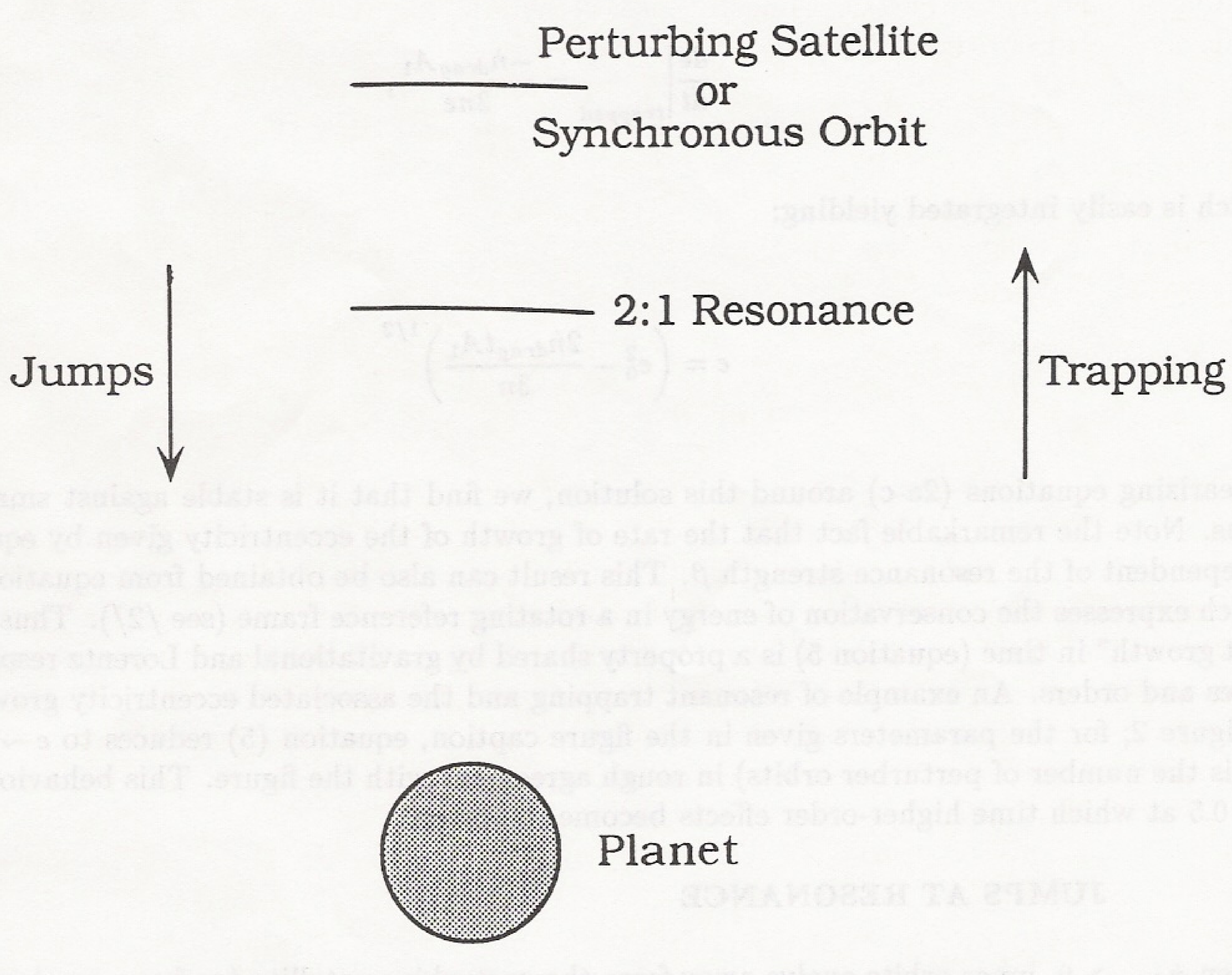

Fig. 1. Schematic diagram showing the central planet, the orbiting dust grain, and the 2:1 resonance. The outermost line represents the location of the perturbing satellite (for a gravitational resonance) or of synchronous orbit (for a Lorentz resonance). A grain drifting through a first-order resonance toward this location may become trapped while one drifting away from it will experience a jump.