• Is our solar system stable?

• Poincare showed that whenever there are homoclinic intersections then one has sensitive dependence on initial conditions.

• Nowadays we know the current position and velocities of solar system bodies more accurately yet they are nowhere close enough to make long-term predictions.

• One needs to answer two questions: does chaos exist in planetary trajectories and if chaos exists, is it pronounced enough to lead to ejection of a body or collision.

• In 1988, Sussman and Wisdom built a machine (Digital Orrery) to calculate an 845 Myr (Myr=1 million years) prediction of the gravitational equations of the solar system.

• Figure 2.32 shows the trajectory of Pluto for two slightly different initial conditions.

• If we envisage a straight line of the curve, we have a slope close to $\frac{1}{12}$ meaning that the distance is being multiplied by a factor of $e^{1/12}$ every Myr or 2.718 every 12 million years.
Another simulation without pluto concluded that the exponential separation of the inner planets is 5 Myrs.

Note that the distance from the sun to the earth is $e^{1.9}$. Thus a distance uncertainty of 1km could grow to 1AU in $19 \times 5$ Myrs. The age of the solar system is much older than that!!

This does not imply disaster yet it stops us from making predictions.

Other research has shown that for a simple system with no moon, for example Mars, the obliquity can oscillate erratically by dozens of degrees in 45Myr for some initial conditions. For others its regular oscillations.

Fig 2.33(b) shows the obliquity modelling of Mars for the last 10 Myrs. Note the abrupt change about 4Myrs ago from 35 to 25 degrees obliquity.

No one knows if these models are true or not, yet they could actually dis-spell some environmental threats.

Yet chaos has been used to save some money for NASA to direct a satellite towards a comet (see page 103).