

VIRIAL THEOREM $\langle PE \rangle = - \langle KE/2 \rangle$

- Simplest case is just circular orbit and is easy to show...but the Virial Theorem is very generally true when take time averages of statistically random motions in a BOUND system.
- Wide generality in physics e.g. Dark Matter was found because more galaxies had more KE than can be contained by PE associated with mass in light-emitting stars.
- **For a gas cloud: Jeans Mass Criterion**
 - KE of the particles (atoms) = $N \cdot 3kT/2$ (1/2 kT per degree of freedom)
 - PE for a spherical cloud $U = -3GM^2/5R$ (just quoted – get by stripping off shells)
 - ➔ Virial Theorem becomes:
 - $N \cdot 3kT/2 = - [3GM^2/5R]/2$
 - $3NkT = - 3GM^2/5R$
 - $N = \text{number of particles} = \text{Mass of cloud}/\text{average mass of particles} = M/m$
 - $M = 4\pi R^3 \rho / 3 \rightarrow R = [3M/4\pi\rho]^{1/3}$
 - ➔ Condition for collapse becomes:
 - $M > [5kT/Gm]^{3/2} [3/4\pi\rho]^{1/2}$ (NB in Melvin's notes $m = \mu m_H$)
- This is the Jeans mass condition for collapse of a cloud under gravity