A few notional time scales

- crossing time $t_c = \frac{2R}{v}$ $\quad \frac{\text{diameter}}{v \text{ or } \sigma}$

typical time to go from one side of a system to the other

Question: will an O star live many crossing times?

- dynamical time $t_d = \sqrt{\frac{3\pi}{16 G \rho}}$

typical orbital time in homogeneous sphere of density ρ

- relaxation time $\frac{t_R}{t_c} = \frac{N}{48 f^2} \approx \frac{N}{6 \ln(N/2)}$

↳ N objects carrying a fraction f of the mass

typical time to forget initial conditions

for smoother MW w/ $N \approx 10^{11}$, $t_R \gg$ age of Universe

for grainier GC w/ $N \approx 10^6$, $t_R \approx 10$ Gyr ~ age of Universe

Relaxation is the cumulative result of many weak gravitational encounters that only nudge the vector $\alpha = \frac{\Delta V_\perp}{V} = \frac{2Gm}{bV^2}$

Strong encounters (w/ ΔP.E. ~ K.E.) are rare in the solar neighborhood $t_{strong} \sim 10^{15}$ yr $\gg H$

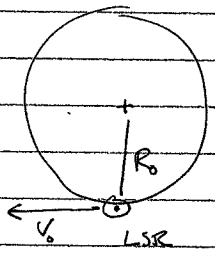
Galactic Structure & Kinematics

How to find

R_0:	V_0:
- Centroid of Globular Clusters	- solar motion wrt G.C.s (but do GCs rotate?)
- " " Halo tracers (e.g. RR Lyrae)	- Proper motion of Sgr A* (need R_0!)
- kinematic $v_r = 0$ along $d = 2R_0 \cos(2\ell)$	- local escape velocity -
- expanding masers @ G.C. $R_0 = 7.9 \pm 0.8$ kpc	$V_{esc} \simeq \sqrt{2}\, V_c$ ($\sqrt{2}$ depends on details of the mass model)
	Sharp cut-off in * stars with $v > V_c + 63$ km/s

Galactic Constants

V_0, R_0



R_0 = distance to Galactic Center

$\approx$ 8 kpc $\pm$ 0.5 all systematics

7.9 - 8.3 recently

V_0 = orbital velocity of LSR ↳ also called Θ_0

$\approx$ 230 km s^{-1} $\pm$ 20 all systematics

official IAU values 220, 8.5 for many years

angular velocity of LSR now pretty well known from proper motion of Sgr A*

$\Omega_0 = \frac{V_0}{R_0} \approx 30$ km s^{-1} kpc^{-1} $\pm$ 0.5 or so

measured with VLBA long after IAU values were set

Oort constants

A local Shear (differential rotation)

B Vorticity (spin or circulation of local fluid element)

$A \approx 15$ km s^{-1} kpc ; $B \approx -13$ km s^{-1} kpc^{-1}

Also C & D ≈ 3 km s^{-1} kpc^{-1} for non-axis-symmetric potentials e.g. the Galactic Bar

K epicyclic frequency

$K \approx 37$ km s^{-1} kpc^{-1}