Astr 509: Astrophysics III: Stellar Dynamics

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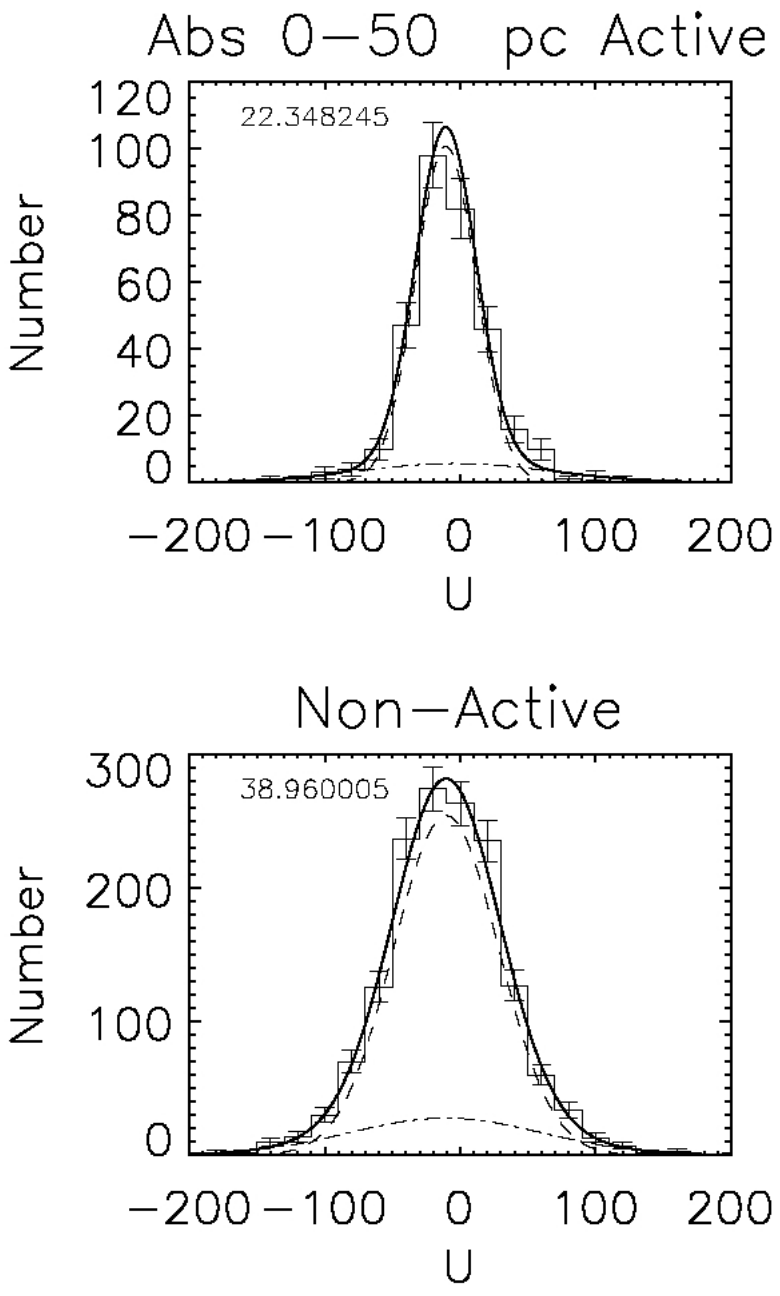
Lecture 14: Collisions II

Scattering of Disk Stars



Boo-chanski et al. (2005)

Scattering of Disk Stars

- Hot blue stars have smaller velocity dispersions than cool red stars; metal-rich stars have smaller velocity dispersions than metal-poor stars
- Boo et al.: Active (presumably young) M dwarfs have smaller velocity dispersion than non-active M dwarfs
- The imperfections in the Galaxy's gravitational field cause the random velocities of stars to increase: the velocity dispersion increases with age: $\sigma \propto t^{1/2}$
- The irregularities responsible for this phenomenon range in scale from small such as molecular clouds, to large such as spiral arms
- Can we (at least qualitatively) understand this behavior?

Scattering by molecular clouds

Typical clouds: up to 10^6 $M_\odot$, <100 pc

Spitzer & Schwarzschild (1953) proposed their existence, motivated by the correlation between the velocity dispersion and age, *before* the first ones were detected!

A star has a relative speed with respect to a cloud because of differential rotation. The successive encounters will increase the star's random velocity.

Prediction: $\sigma \propto t^{1/4}$ slower than observed

Another difficulty: can explain σ of up to 30 km/s, but white dwarfs and C stars have $\sigma \sim 50$ km/s

Scattering by spiral arms

N-body simulations: spiral arms can heat the disk

The spiral structure heats the disk, which decreases the efficiency of the swing amplifier until the spiral structure cannot be maintained.

Thus the spiral structure is killed by the heat that it injects into the disk, just as yeast in a vat of fermenting beer is killed by the alcohol it creates.

Important: a fixed spiral pattern cannot heat the disk – the arms must be transitory (see BT figs. 7-26 and 7-27)

Note that within Lin-Shu theory disk heating is negligible; the stochastic theory predicts significant disk heating

Prediction: $\sigma \propto t^{\alpha}$, with $\alpha \sim 0.2 - 0.5$

Scattering by spiral arms

Problem: the velocity dispersion increases only in the radial and azimuthal directions. What about the vertical dispersion?

Carlberg (1984): spiral arms provide heating in the radial and azimuthal directions, which molecular clouds redistribute in the vertical direction.

Lacey & Ostriker (1985): the heating is due to 10^6 $M_\odot$ black holes from the halo.