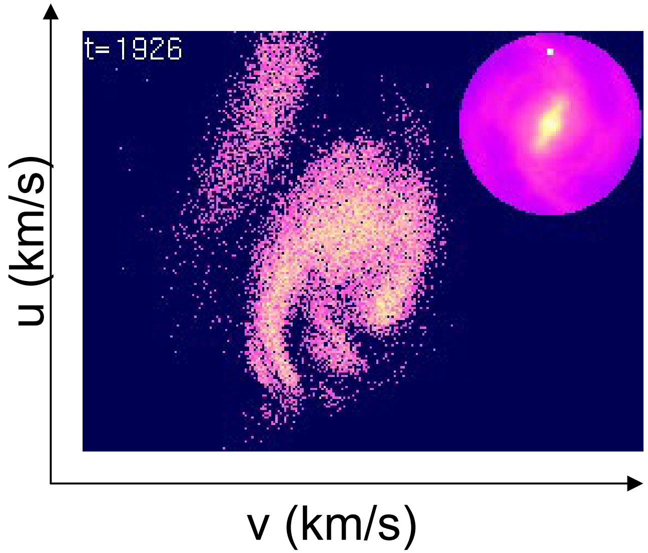
Example: N-body simulations of Milky Way

R. Fux 1999, A&A 345, 787 and 2001, A&A 373, 511

Dark Halo + stars (Particle-mesh N-body code) + interstellar gas (SPH particles)

evolution from 1925 to 2300 Myr of the velocity distribution in the U-V plane of the disc particles within a fix vertical cylinder of 0.5 kpc radius and at a galactocentric distance of 8 kpc.

the observing cylinder is comoving with the bar in a way such that its azimuth always lags the bar major axis by 25 deg and its galactocentric distance remains at 1.1 relative to the outer Lindblad resonance.



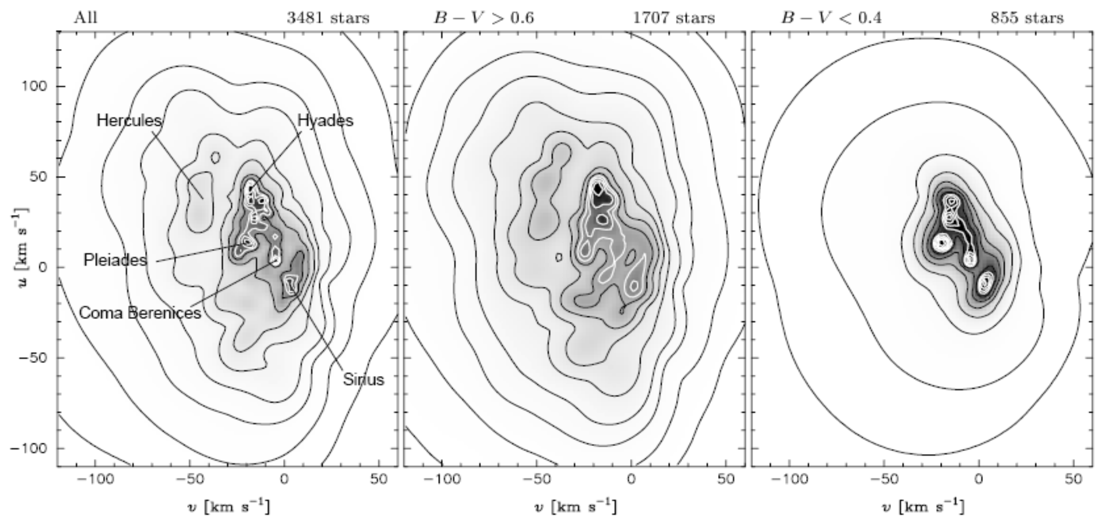
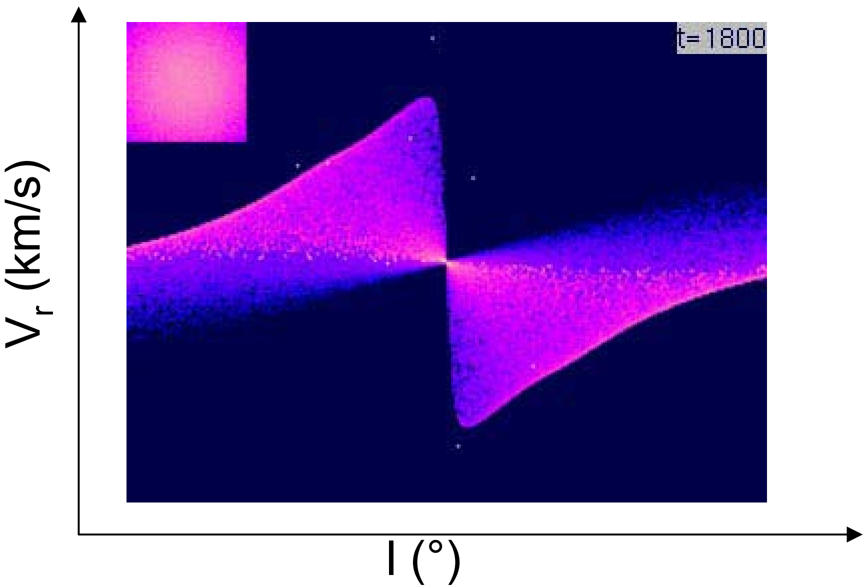


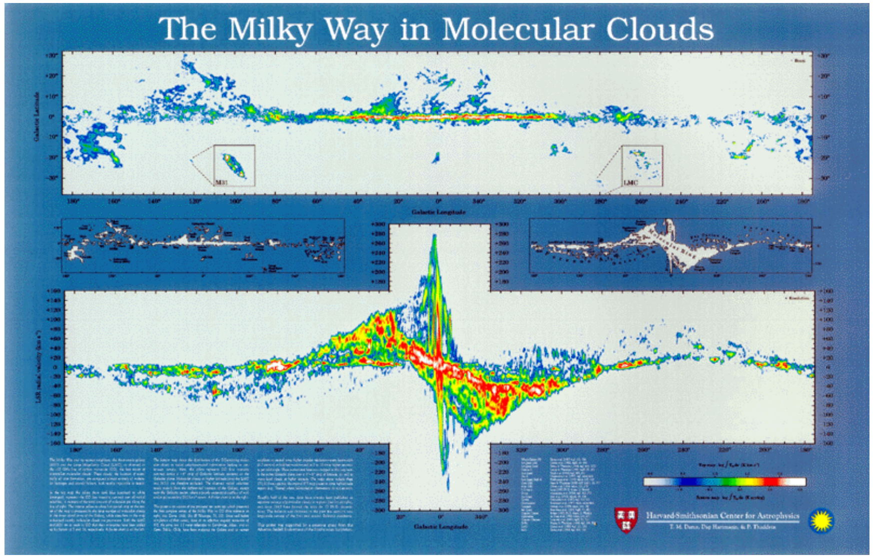
Fig. 1. Heliocentric velocity distribution in the $u-v$ plane of all the Hipparcos single stars with $\sigma(\pi)/\pi < 0.1$, $d < 100$ pc and radial velocities in the Hipparcos Input Catalogue (left) and of the sub-samples with $B-V > 0.6$ (middle) and $B-V < 0.4$ (right). For the sake of comparison, the contours are as in Dehnen (1998), containing 2, 6, 12, 21, 33, 50, 68, 80, 90, 95, 99 and 99.9 percent of all stars. The diagram for the full sample is exactly the same as in Fux (2000), except for a different labelling of the contours.

comparison with the observed stellar velocity distribution in the Solar neighbourhood inferred from the Hipparcos data.

longitude-velocity diagram of the gas within |b|<2 deg for an observer at rest 8 kpc away from the centre of mass, for |l|<90 deg and |V|<288 km/s. The contribution of each SPH particle has been weighted by the inverse of its square distance to mimic the flux fall-off of light.

the observer is corotating with the bar, with the major axis of the latter being always inclined by 25 deg relative to the direction l=0, and that |l|<64 deg.





Some sequences of this movie closely resemble the observed HI and CO l-V diagrams. Fux's simulation strongly suggests that most features appearing in these data within |l|<30 deg must be of transient nature (1700K).

Data in Euclidian 3D space (geometrical)

- Non-'x, y, z' axes but still in 3D space
  - Examples of 'others' coordinates:
    - cylindrical (R,θ,z), spherical (ρ,φ,θ), …
    - Galactic (projected) coordinates (l,b)
  - Each axis has its own units (or no units, i.e. radians)
  - Some of them could be periodic (φ,θ)
- Use cases:
  - Most astrophysical objects have symmetries ⇒ meshes adapted (polar, spherical…)
- Solution: conversion from/to Cartesian coordinates generally easy
  - A service (server side) could be implemented to convert 'others' → x,y,z

Data in Euclidian 3D space (non geometrical)

- Axes in physical space?
  - Examples of ‘physical’ distance measuring tools:
    - Eccentricity (dynamics of solar system)
    - Optical depth (modelisation of molecular clouds)
    - Temperature (stellar atmosphere)
    - Redshift
  - Defined by some one-to-one relationship with a space coordinate
    - In such a case, could a service be implemented to make conversion?
  - Other physical quantities:
    - Used in some mesh-based codes
      - Velocities (u,v plane; radial velocity, etc.)
      - Entropy in phase-space (COSMO3D) or distribution function (galactic modelling)
      - Density as a function of pressure, numerical density (cm^{-3}), etc.
    - Wavelength/frequency (e.g. power spectra)
    - How many such cases?

Data with n≠3

- Extra-dimensions (n>3) ?
  - The most obvious is time
    - Is implicit ('snapshot') in SNAP: 1 query by snapshot
    - 'orbits' (x(t), y(t), z(t)) not handled (P. Teuben's case; 1 orbit by query)
  - Phase space coordinates (x, y, z, vx, vy, vz)
    - N-body snapshots are lists of phase space coordinates
    - But vx ≡ vx(x,y,z) etc. in most case
      - Exceptions: Entropy or distribution function in phase-space
  - SPH particles properties:
    - Same as N-body + density, smoothing length, pressure, temperature…
    - But P ≡ P(x,y,z) in general
  - Eulerian (hydro) codes:
    - All quantities defined on a mesh
- n=1 or n=2 data
  - A priori possible in SNAP