

# Exploiting Large Surveys for Galactic Astronomy

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- Galaxy Formation and the Milky Way
- Surveys from the ground and from space
- Challenges and Opportunities

# Galaxy Formation

- Much world-wide observational effort, much of it aimed at distant Universe (far away = long ago)
- Numerical simulations now have resolution to model individual galaxies
- Motions and properties of old stars contain *'fossil record'* of formation history
- The fossil record can be read in detail in the Milky Way, and its nearest neighbors

# The Key Science Goal

- The Milky Way is an 'average' galaxy, in a representative (local) group
  - Understanding its formation is central to entire field of galaxy formation
    - Paradigm: hierarchical merging of many small building blocks
  - We need to determine:
    - When the stars in the Milky Way formed
    - When and how the Milky Way was assembled
    - How dark matter in the Milky Way is distributed
- (Wyse, Bland-Hawthorn, Helmi)

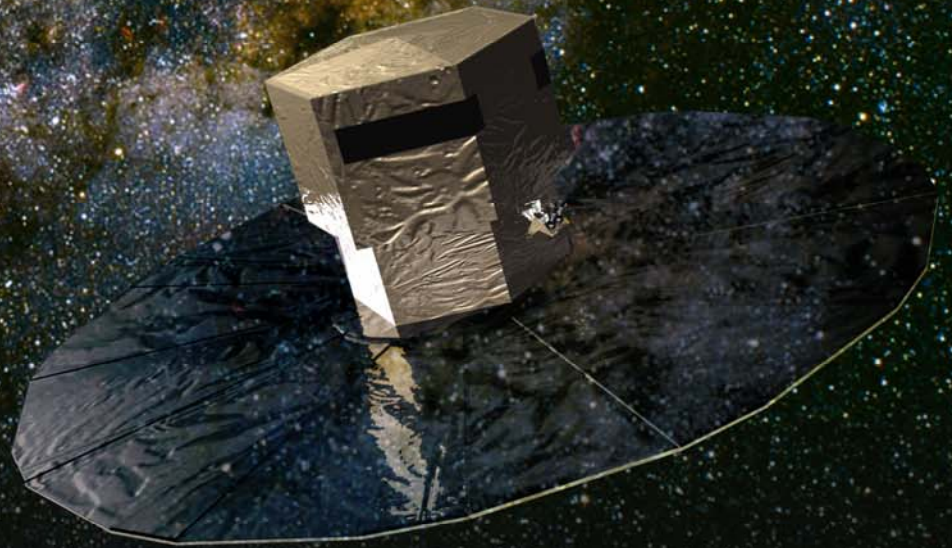
# Surveys

- Photometry (Newberg, Ivezić, Ishihara, Kaiser)
  - 2MASS, SDSS/SEGUE, Akari, VST/MISTA, PS1
  - PS4, LSST
- Radial velocities (Ivezić, Holmberg, Steinmetz)
  - Geneva/Copenhagen, SDSS/SEGUE, RAVE, GAIA
- Proper motions and parallaxes (Turon)
  - HIPPARCOS, groundbased fainter catalogs
  - GAIA (+ planned US and Japanese initiatives)
- Stellar parameters:  $T_{\text{eff}}$ ,  $\log g$ ,  $A_V$ ,  $[\text{Fe}/\text{H}]$ ,  $[\alpha/\text{Fe}]$ 
  - From the above, plus high resolution follow-up for subset of stars (e.g., Geneva/Copenhagen, Feltzing)

# Kinematics and Abundances

- Many studies now find evidence for kinematic groups with different elemental abundances
  - Not only in halo, but also in thick disk (Feltzing, Helmi)
- Suggestive of merging of building blocks
  - Building blocks  $\neq$  dSph satellites (Helmi/DART)
- Systematic kinematic selection, and follow-up high-resolution spectroscopy, holds much promise for unraveling formation history (B-H/Freeman)
  - Unprecedented detail for Milky Way
  - Now also possible for nearest galaxies

# Stereoscopic Census of the Milky Way



# Challenges - I

- Calibration
  - Critical for groundbased photometry (Glass)
  - Derivation of stellar parameters from photometry or spectroscopy needs much attention (Gray)
- Importance of extinction
  - May not be major issue for halo objects, but is crucial for planned studies of disk and Bulge (Robin)
  - Galaxy models can help, with HI, 2MASS, VISTA, and, of course, parallaxes from GAIA!
- Variable stars, including eclipsing binaries
  - Need special attention, multiple epoch observations
  - Provide much additional information (Cook)

# Challenges - II

- Galaxy models need to include dynamics
  - Key step beyond star counts
  - Applied to full GAIA data: massive discriminating power
  - At least three approaches known; need development
  - Also include information on stellar populations
- Preparation is needed now
  - Much experience available (e.g. Besançon model)
  - Approved EU RTN (PI Binney) will start this for GAIA
- This is one example of more general preparation needed to extract science from large databases

# Opportunities

- Explore complementarity of GAIA surveys and groundbased efforts (Bailer-Jones)
  - RAVE/RVS good example for radial velocities
  - Link with deeper synoptic/photometric surveys, which also provide proper motions (PS4/LSST)
  - US & Japanese space astrometry efforts: competition, complementarity, cooperation?
- High-resolution spectroscopic follow-up
  - Dedicated effort with existing instruments (WFMOs?)
  - If new instrumentation needed: develop it now

# Conclusions

- Next decade will see tremendous progress in our understanding of the formation of the Milky Way and the Local Group
- Homogeneous large scale surveys, dedicated follow-up, and theoretical preparation are critical
- Complementarity of ground and space to be exploited further; this is a global undertaking