Halo Streams in the Solar neighbourhood through high resolution observations now and with Gaia

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We explore the solar neighbourhood of the Milky Way using the new kinematic survey we produced by means of spectro-photometric data from the Sloan Digital Sky Survey, and high-quality proper motions derived from multiepoch positions from the Guide Star Catalog II.
We select samples of subdwarfs within few kpc of the Sun which are adoped as tracers of the halo.
We find statistical evidence for discrete overdensities, likely possible accretion remnants, and compare this result to high resolution N-body numerical simulations of minor mergers accreted and present what Gaia will reveal.
Now and in the Gaia era, this knowledge will set the basis for future studies and provide significant clues to constrain the scenarios of the formation and evolution of the Milky Way.

THE SDSS-GSC-II CATALOG:

As predecessor to Gaia we produced a new kinematic survey (Spagna+2009, Lattanzi+2011) combining Astrometric, Photometric and Spectroscopic data from SDSS-GSC-II:

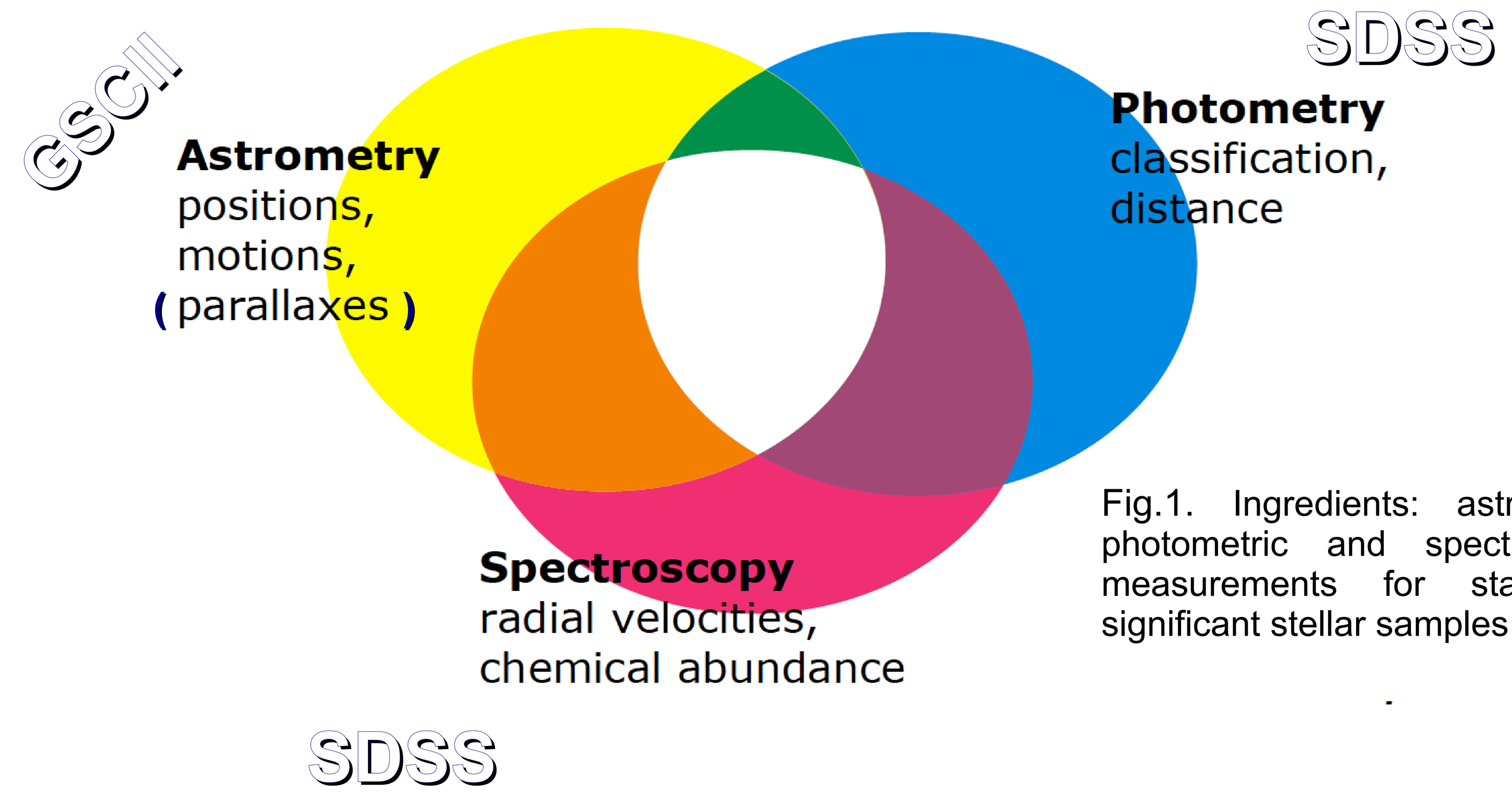


Fig.1. Ingredients: astrometric, photometric and spectroscopic measurements for statistically significant stellar samples

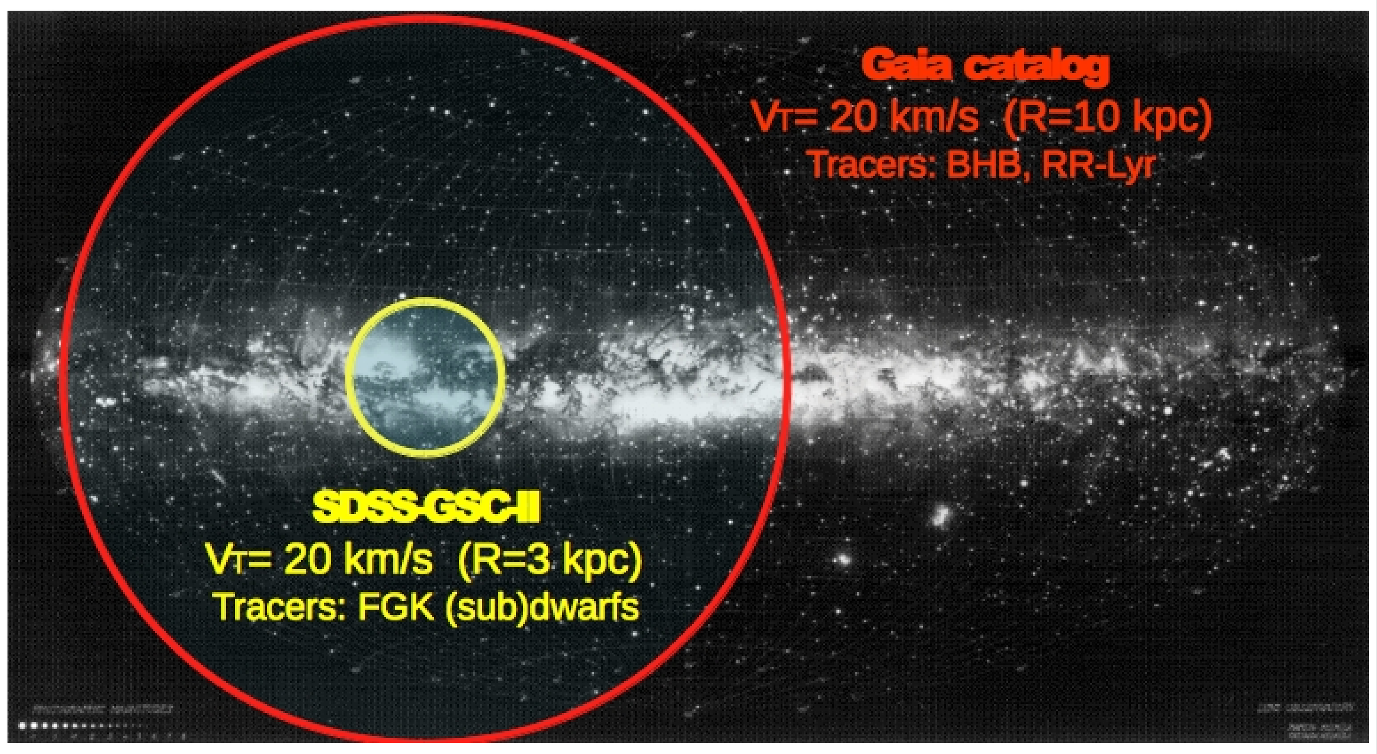


Fig.2. Galactic horizon of the stellar kinematic surveys based on SDSS-GSC-II and Gaia, superimposed on the Lund map of the Milky Way

DATA: (HIGH VELOCITY STELLAR) HALO STREAMS

In a CDM Universe, galaxies like the Milky Way grow by mergers of dwarf galaxies; this theory predicts the presence of substructures due to accretions experienced over their lifetime. Considerable structure is still present in the halo of the Milky Way, indicating that such events have had role in its formation history (e.g. Ibata+1994; Majewski+1996; Helmi+1999; Ivezić+2000; Re Fiorentin+2005; Morrison+2009; Klement+2009).

The Galactic halo may retain memory of its merging history in the form of fossil streams of stars which, although sometimes of very low spatial density, may be detectable as stellar groups with coherent kinematics and metallicities.

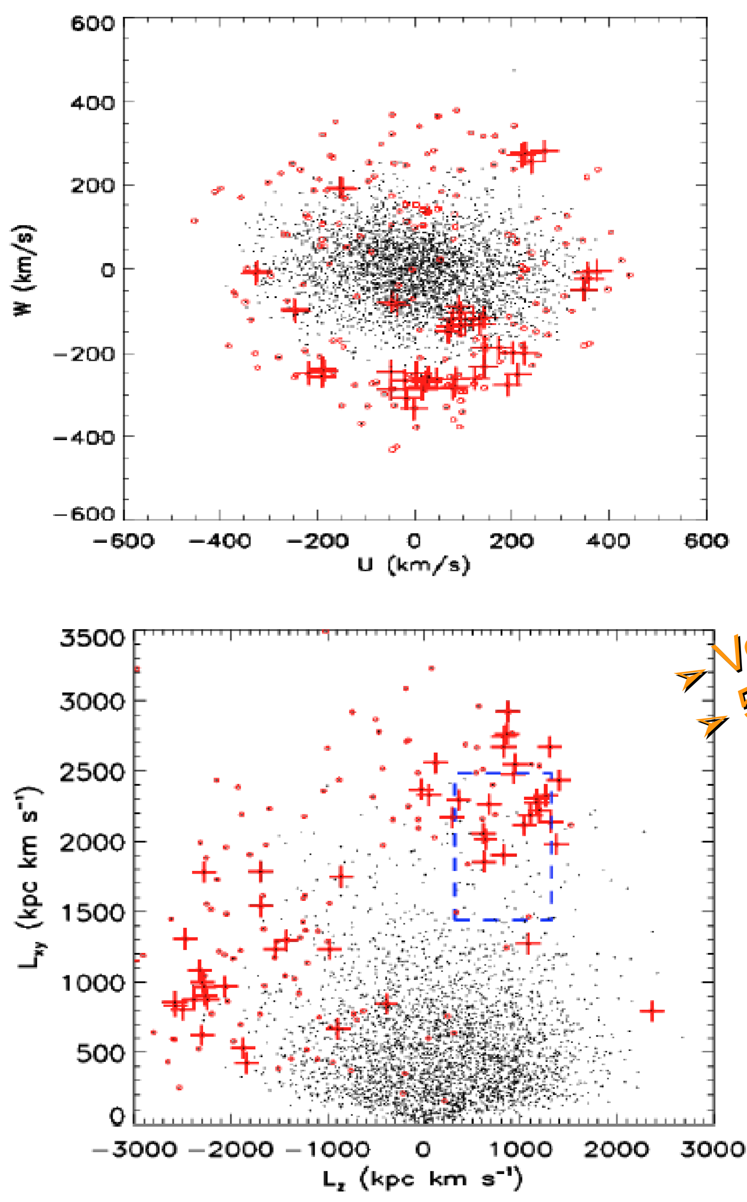


Fig. 3. Kinematic distribution of the observed halo sample: velocity projection UW (top), angular momentum (bottom). Of the 2709 subdwarfs, the 5% fastest are highlighted (red circles). Among them, the crosses identify groups with velocity difference less than 42 km s^{-1}.

➤ Velocity distribution relatively smooth
➤ 5% fastest moving stars are more clumpy!

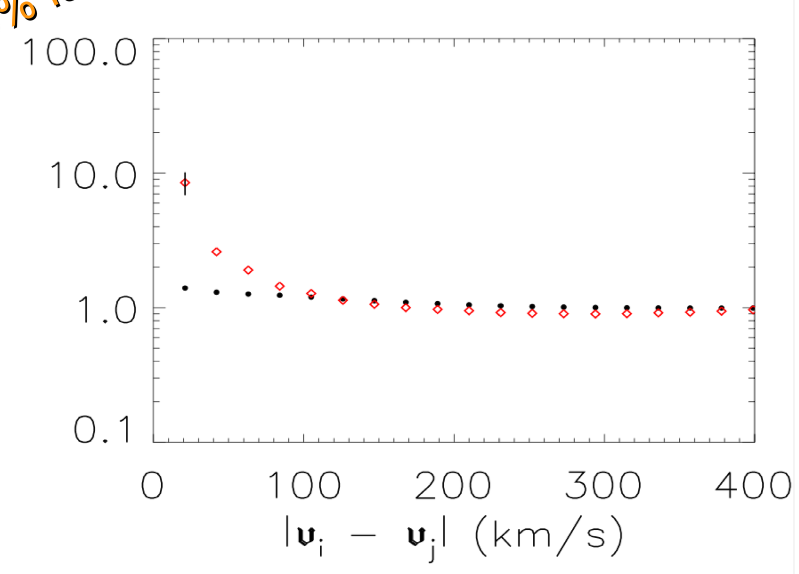


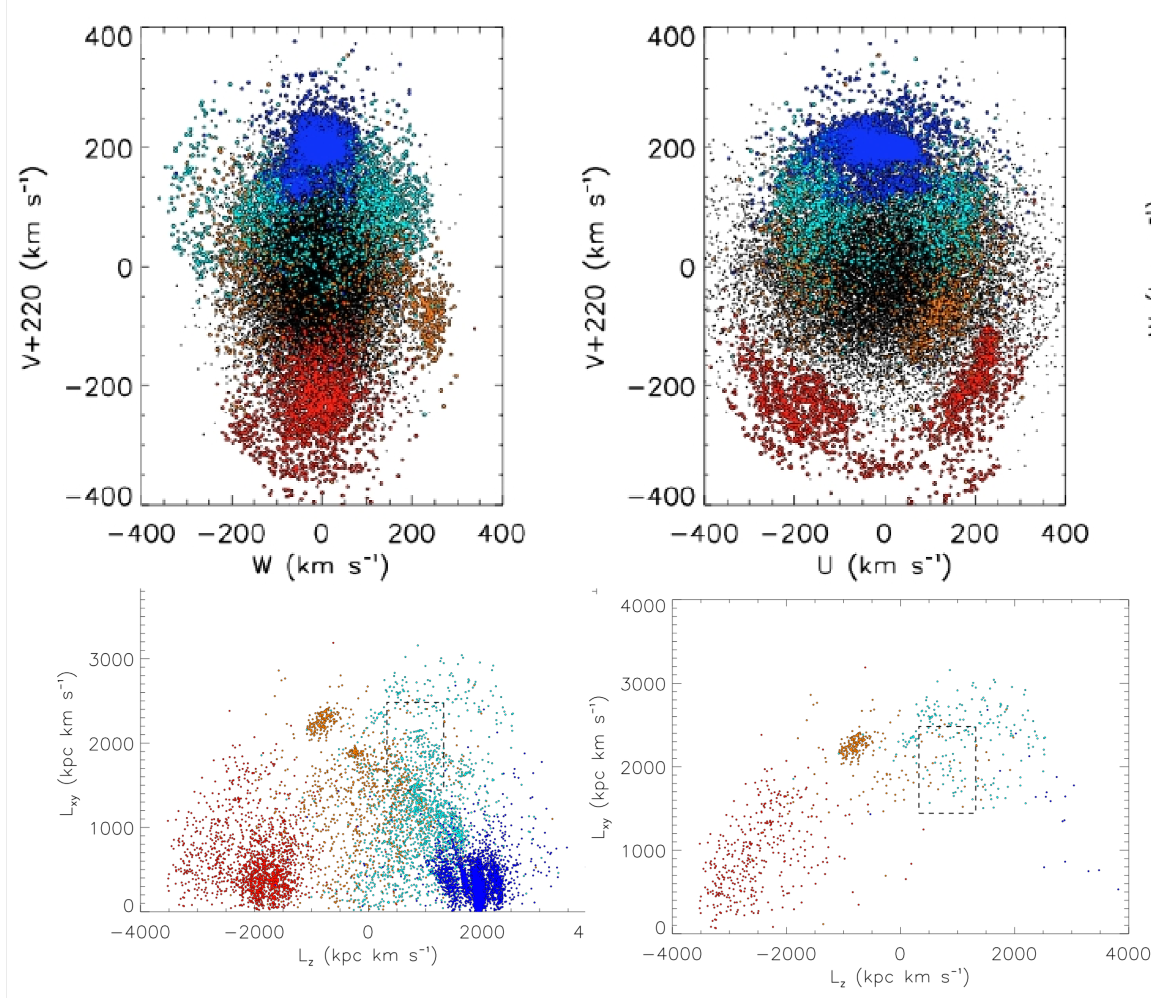
Fig.4. Correlation function ξ for the full size sample (black) and its 5% fastest subset (red).

➤ Clumping due to kinematic substructures (i.e. groups of stars moving with similar velocities) is indicated by an excess at small velocity separations.

☆ **We find statistical evidence of substructure in the space motions of the fastest moving stars. This appears to be due to a small number of moving groups belonging to the outer halo that are even not smoothly distributed in angular-momentum phase space, but rather, are strongly clustered.**
Further investigation of the group members (e.g., chemical abundance and orbits) suggest that they may be possible fossil remnants, whose presence has been encoded in the kinematics and intrinsic properties of its stars.

HIGH RESOLUTION N-BODY SIMULATION:

(zoom@theSun)

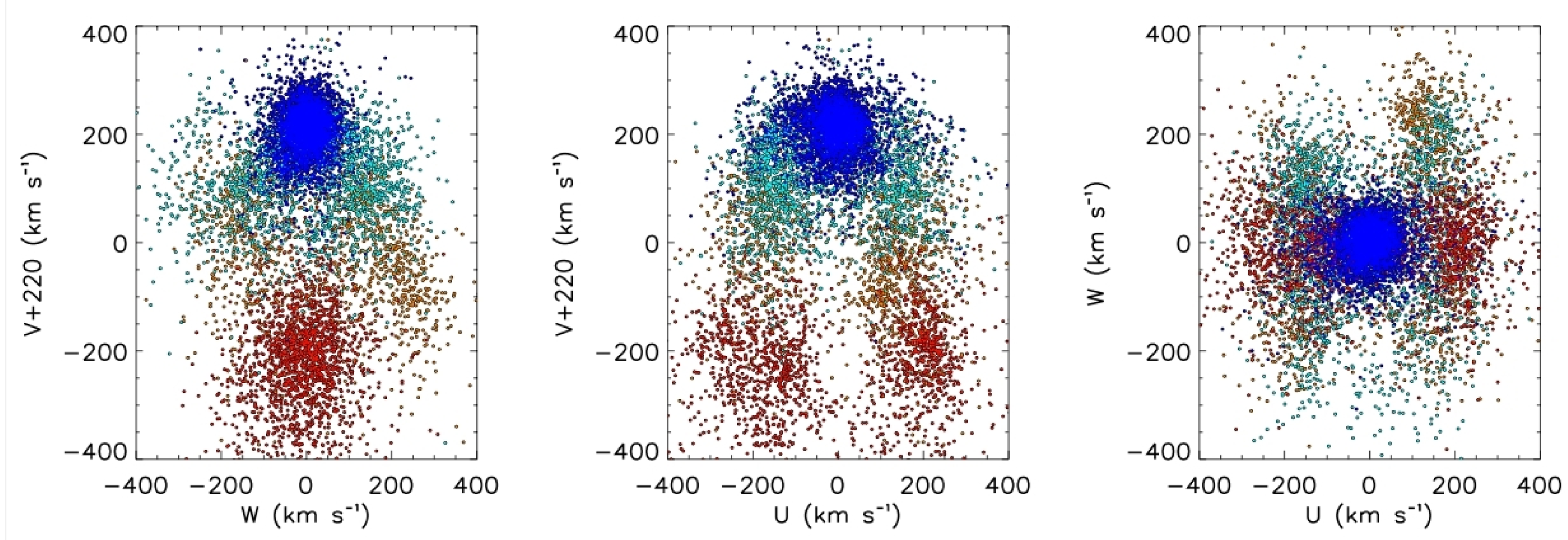


MINOR MERGERS ACCRETED

Fig. 5 Kinematic distribution of the simulated halo: local stellar halo (black), 60° retrograde/prograde (orange/cyan), 10° retrograde/prograde (red/blue).

Angular momenta: 5% fastest subsample on the right.

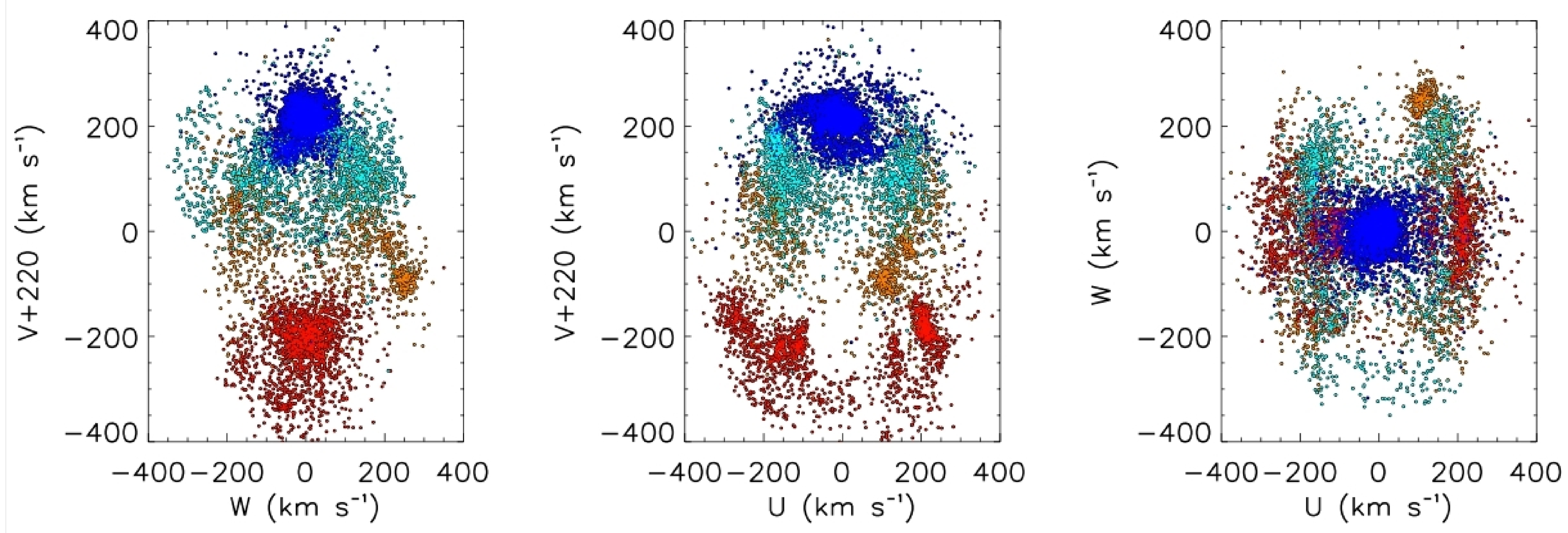
vs SDSS-GSC-II ACCURACY



σ(m-M)= 0.4 mag
σ(μ)= 2 mas/yr
σ(Vr)= 10 km/s
σ([Fe/H])= 0.25 dex

vs Gaia ACCURACY

(complemented with the Gaia ESO Survey, Gilmore, Randich+2011)



σ(π)= 20 μas
σ(μ)= 20 μas/yr
σ(Vr)= 1 km/s
σ([Fe/H])= 0.1 dex

REMARKS:

►We have found statistical evidence of substructure in the space motions of the fastest moving stars, due to a small number of moving groups, possible fossil remnants from high inclination / low inclination retrograde orbits.

►This evidence is supported by high resolution N-body simulations designed to study (four) minor merger of orbiting satellites.
• In the velocity distribution and the angular momentum phase space of the local halo, satellites do appear very coherent.
• Among the subsample of the fastest objects, the regions of high inclination / low inclination retrograde orbits are populated consistently to observed data, according the mechanism of dynamical friction and indicating its important role in the accretion events.
• Convolving true/simulated data with different error distributions according to the accuracy of SDSS & GSC-II and the accuracy predicted for Gaia these findings are confirmed.

►These findings, if confirmed by further studies, are of great importance for constraining models of the formation and evolution of the Milky Way, and structures in the Universe.

►Space astrometric missions, such as Gaia, will collect samples of millions of stars with very accurate positions and kinematics which will dramatically improve the reliability of such conclusions.

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