Local dwarf galaxies and their links to galaxy formation

Hanni Lux

SEVENTH FRAMEWORK PROGRAMME

MARIE CURIE ACTIONS

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

The proximity of the satellites of our own Milky Way yield a unique data set with which we can test galaxy formation models down to very small scales. We use a hires dark matter only simulation of a Milky Way analogue to address the question of how well the orbits of the local dwarf galaxies can be determined while accounting for typical model and measurement errors. Applying these results to the 'classical' dwarf galaxies around the Milky Way we find that their mean apocenter distribution is consistent with the most massive satellites that formed before z=10. This agrees with the notion that dwarf galaxies formed before reionisation.

Introduction:

- Understanding the orbits of the dwarf galaxies around the Milky Way (MW) is vital for our understanding of the dependence of galaxy formation on environment, and testing our standard cosmology.
- Since the Milky Way evolves over time, we can expect our ability to recover orbits to deteriorate over long timescales. Here we quantify how well we can do in the face of realistic measurement errors, and a time varying Milky Way potential.

Methods:

- We compare satellite orbits from the hires dark matter only simulation of a MW analogue Via Lactea (Diemand et al. 2007) with results from backwards orbit integration (cf. Fig.1).
- For this we use the z=0, 6D initial conditions from the simulation and integrate the satellites in a fixed potential - a spherical NFW profile.
- We further test the effects of dynamical friction, mass loss of the satellite, mass evolution of the mail halo and triaxiality of the main halo on the orbit recovery.

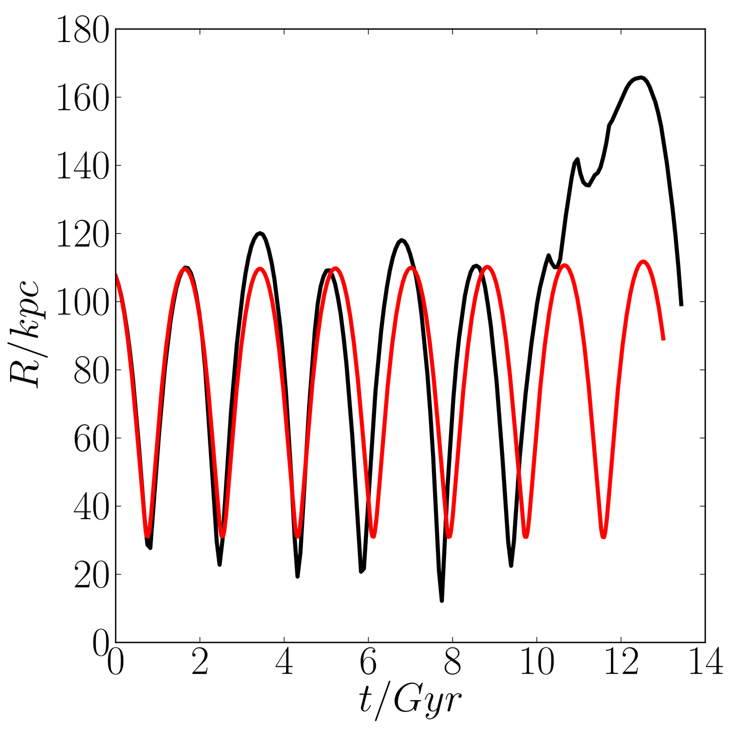

Fig.1: Distance to the host galaxy vs. lookback time for the Via Lactea orbit (black) and the integrated orbit (red).

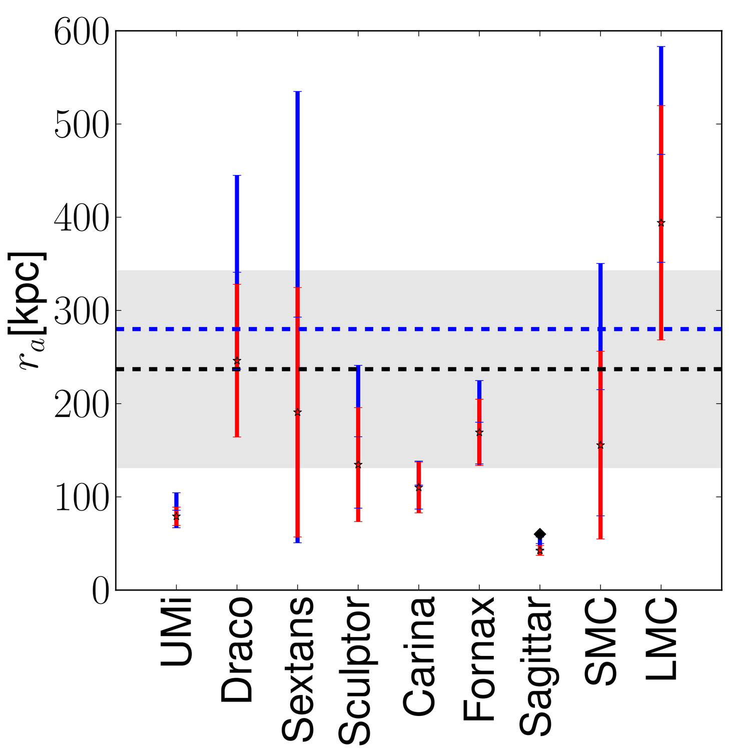

Fig. 2: Apocentre distribution of the 'classic' MW dwarfs in comparison to the surviving 50 most massive satellites in Via Lactea at z=0; these distributions are not consistent with each other

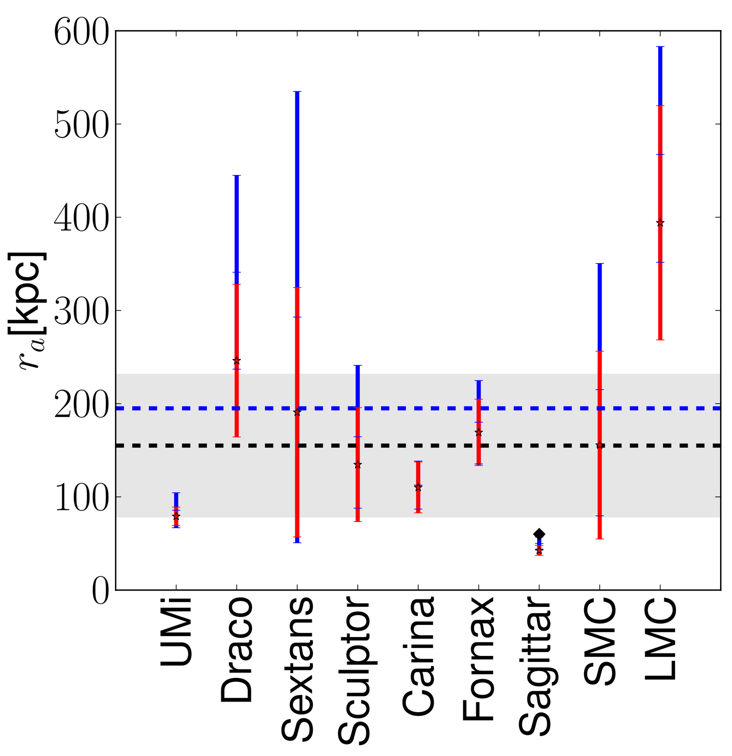

Fig. 3: Apocentre distribution of the 'classic' MW dwarfs in comparison to the surviving 50 most massive satellites in Via Lactea before z=10; both distributions are consistent with each other

Legend: the grey band denotes the spread and the dashed black line is the mean of the distribution in VL, the blue dashed line is the mean corrected for the bias from the measurement errors; The blue error bars denote orbits in the Law et al. (2005) MW potential and the red error bars in the Wilkinson and Evans (1999) potential.

Results:

a) *Model Errors*

- Using the correct potential shape is essential for the accurate orbital recovery.
- Independent of the specific orbit integration model used apo-/pericentres cannot be recovered for more than 2 orbits backwards in time
- This is mainly due to the fact that many satellites that fall into the galaxy within a group and exchange energy with other satellites

b) *Measurement Errors:*

- With current measurement errors, apo-/pericentres can only be recovered with errors of ~40%
- This will improve to ~14% in the Gaia era for up to 2 orbits in the past
- However, measurement errors bias the mean of the apo-/pericentre distributions high, this has to be taken into account when comparing with simulations (blue dashed line Fig. 2+3)
- Comparison with real data shows that the apocentre distribution of the 'classical' MW dwarfs is more consistent with the distribution of the 50 most massive satellites in VL before z=10 than of the 50 most massive satellites at z=0 (cf. Figures 2+3)
- Due to the large current errors, a correlation between pericentre passages and star formation histories can neither be confirmed nor refuted (cf. Fig. 4).

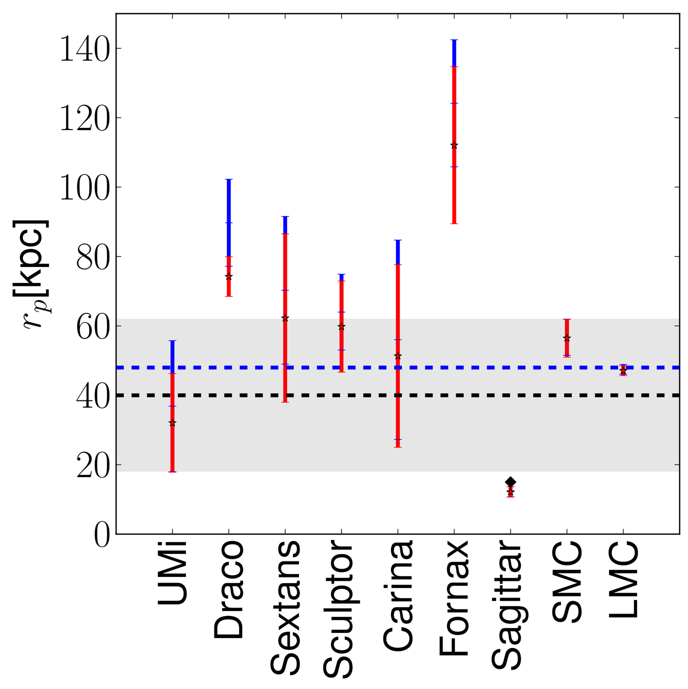

Fig. 4: Pericentre distribution of the 'classic' MW dwarfs in comparison to the surviving 50 most massive satellites in Via Lactea at z=0, the dwarfs are ordered by their star formation histories from mainly early (e.g. UMi) to significant recent star formation (LMC,SMC); however, the data is too inaccurate to confirm/refute any correlations

Conclusions:

- Model errors occur from a time-varying, triaxial potential and satellite-satellite interactions during group infall.
- Currently measurement errors are dominating, allowing for apo-/pericentre recovery with errors ~40%
- In the Gaia era, model errors are dominating, allowing for apo-/pericentre recovery with errors ~14% up to N=2
- Current apocentre distribution consistent with most massive halos at z=10
- With current data a correlation between pericentre passages and star formation histories can neither be excluded nor verified

References:

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