The weak lensing radial acceleration relation

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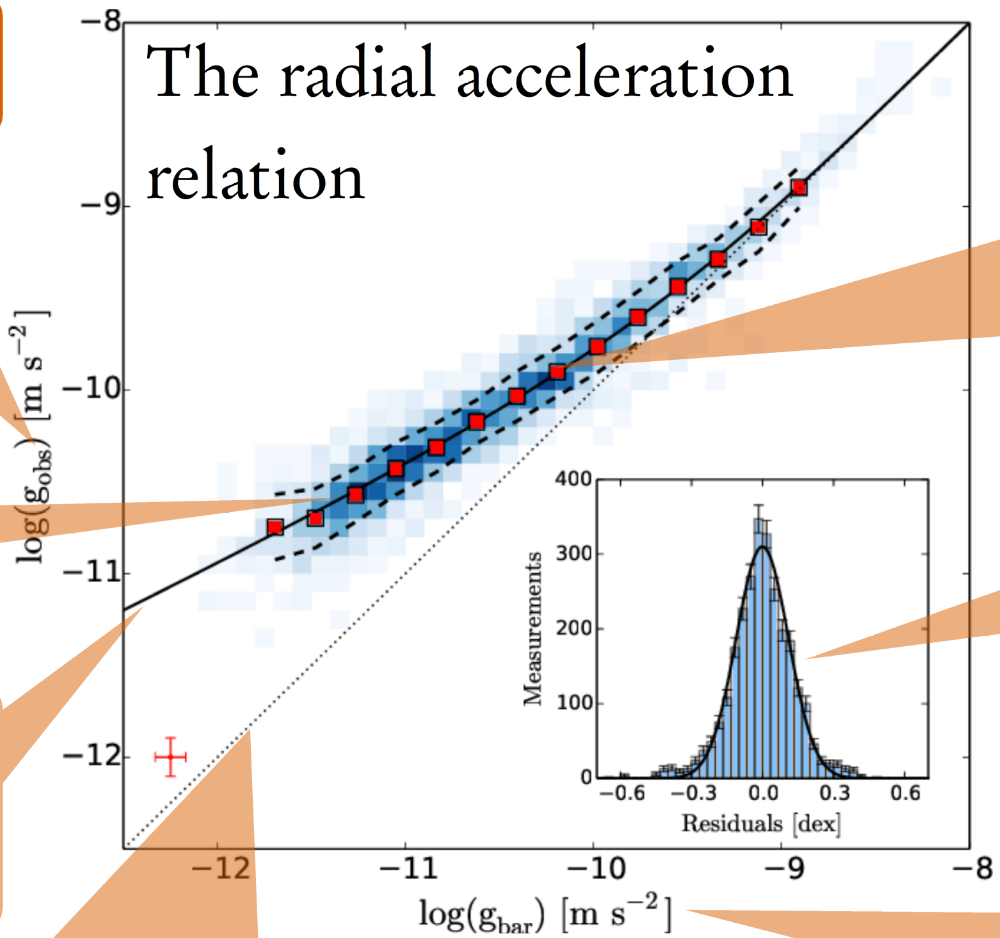
I. Context

(Total) gravitational acceleration
as traced by kinematics
– or lensing!

Upward bend due to:
dark matter? MOND?

Pushing to lower accelerations can discriminate between theoretical interpretations



Strong correlation between visible matter and kinematics in late-type galaxies across a wide range in galaxy properties

Narrow scatter: RAR is a fundamental scaling relation for galaxies?

Gravitational acceleration due to baryons: closely related to star+gas surface brightness (or density)

On the $g_{\rm obs} = g_{\rm bar}$ diagonal,
visible matter explains observed dynamics

Figure: McGaugh et al. (2016)

II. Method

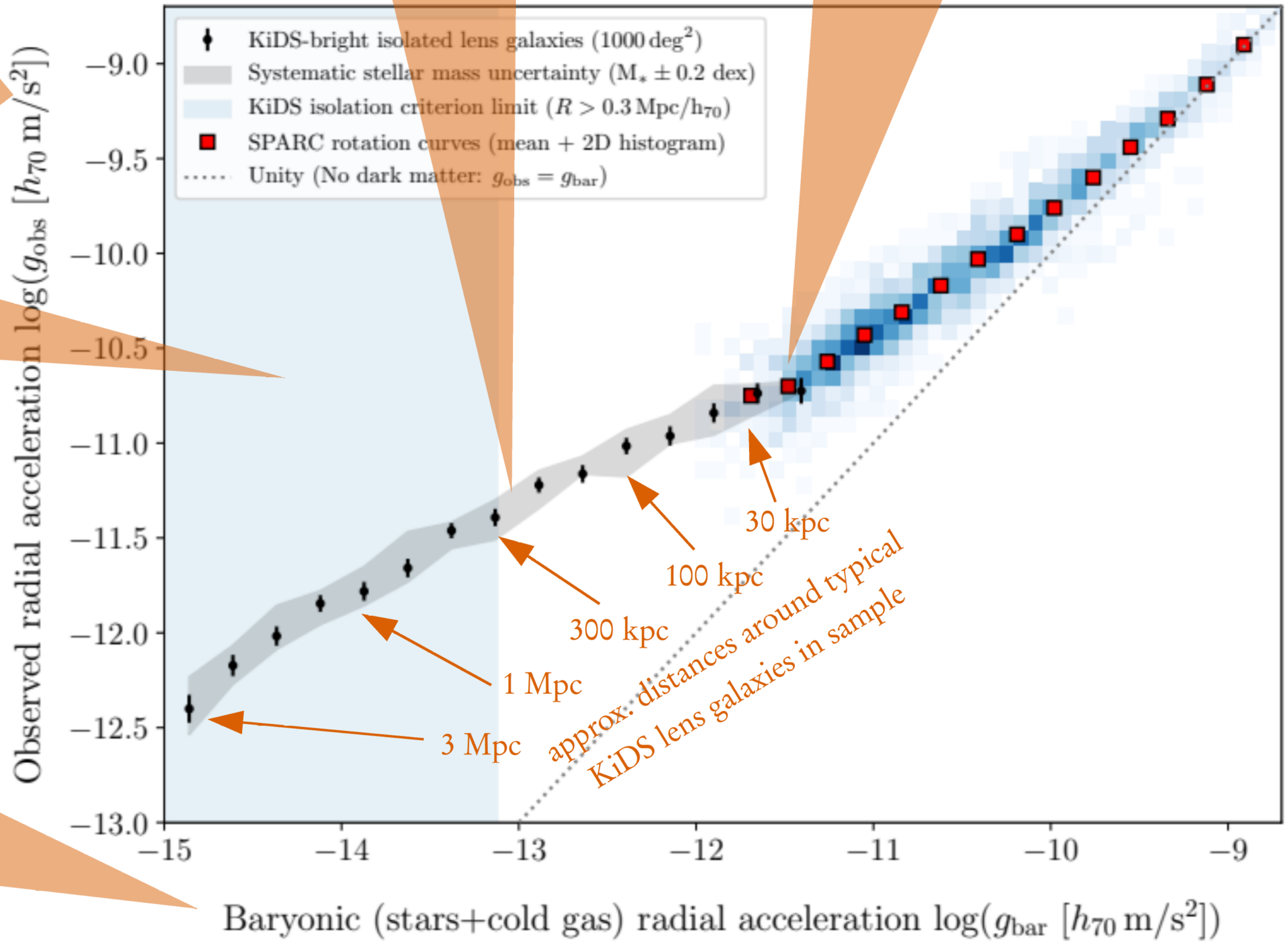
From KiDS 1000 sq. deg.
We selected isolated lenses – no neighbours within 3 Mpc.
From the convergence signal, we measure the implied gravitational acceleration.

Shaded region: “isolated” selection becomes uncertain.
Neighbouring galaxies may contribute to g_{obs} signal.

The expected acceleration due to observed stars and cold gas.
Hot gas conspicuously missing.

The weak lensing RAR

Excellent agreement with 21-cm rotation curve-based measurement in overlap region.
Surprising given differences in galaxy samples?

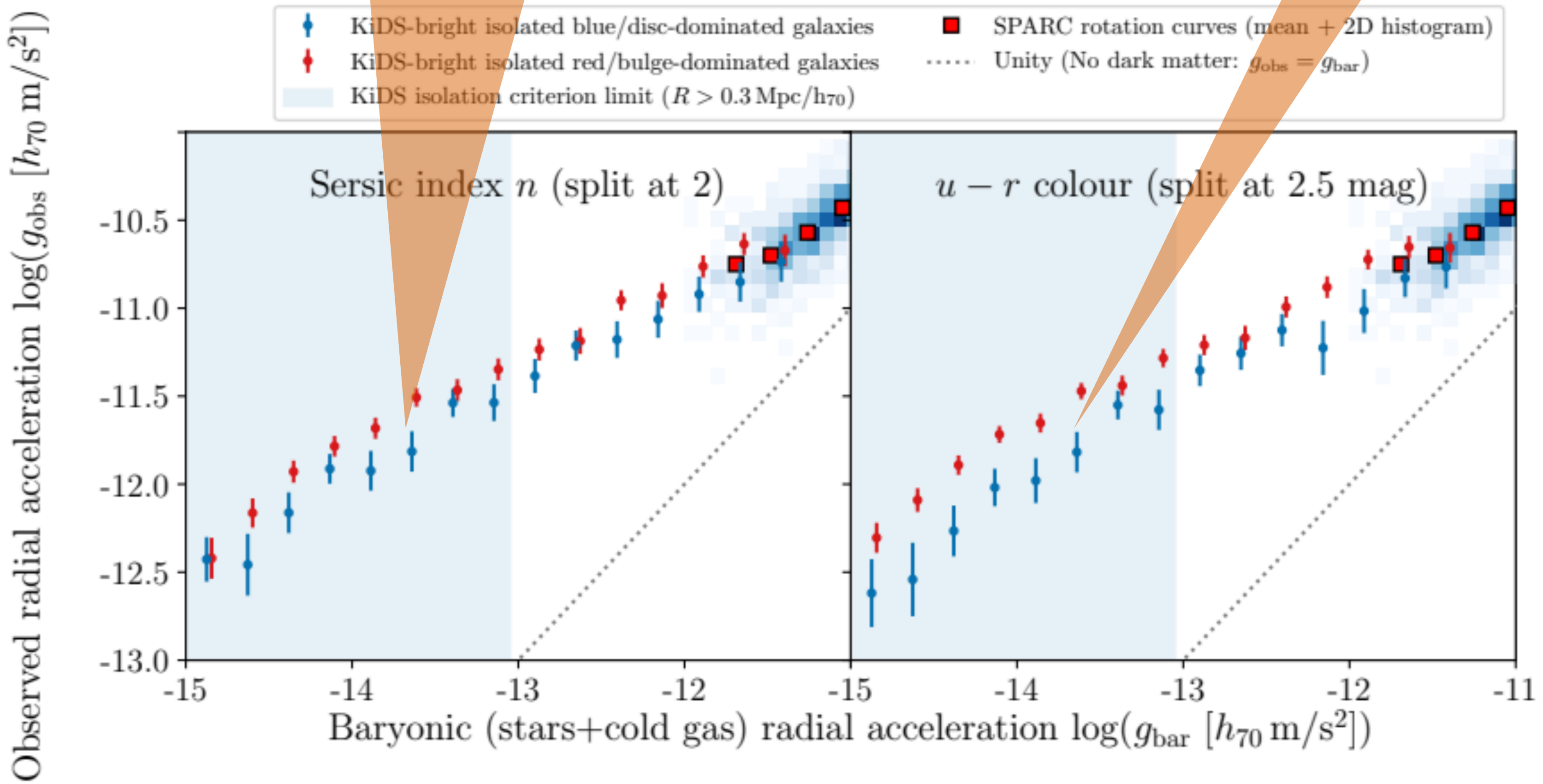


III. Results

Early-type galaxies (red points) have a systematically different RAR relative to late-types (blue points).

Offset may be difficult to explain in terms of MOND or other non-GR gravity theories (e.g. Verlinde's EG). Differences in hot gas content (plausible!) may keep the "universal RAR" hypothesis viable, though.

Similar offset for red vs. blue galaxies (n.b. colour and Sersic index correlated).



IV. Interpretation

No theoretical model yet shown to satisfactorily explain measurement. CGM constraints would help discriminate.

MICE N-body + halo occupation distribution/abundance matching ΛCDM sim. Excellent match to KiDS, but failure to reproduce trend in lensing signal with degree of isolation of lens galaxy: match by “luck”.

Emergent gravity prediction very similar to that for MOND.

Basic MOND prediction: significant offset from KiDS measurement. Neither addition of hot gas contribution to g_{bar}, nor accounting for external field effect, seem likely to ameliorate this.

BAHAMAS cosmo-hydro ΛCDM sim undershoots KiDS substantially. Probably related to relatively poor reproduction of stellar-to-halo mass relation? Could be verified with sims that calibrate on SHMR, e.g. EAGLE, TNG...