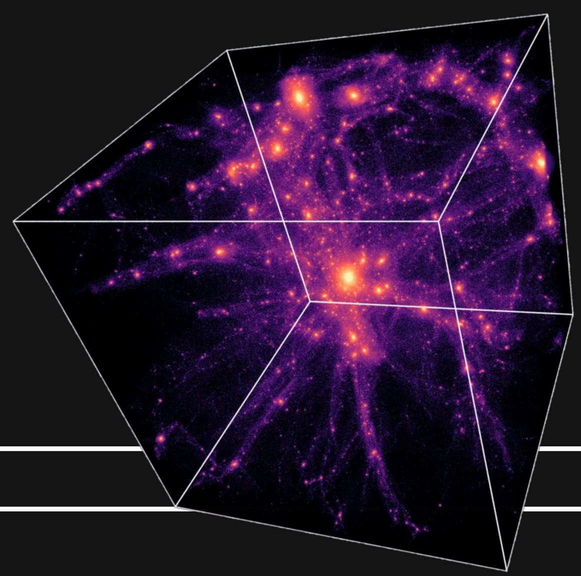
Using EAGLE to Investigate Intrinsic Galaxy Alignments in Radio Weak Lensing Surveys



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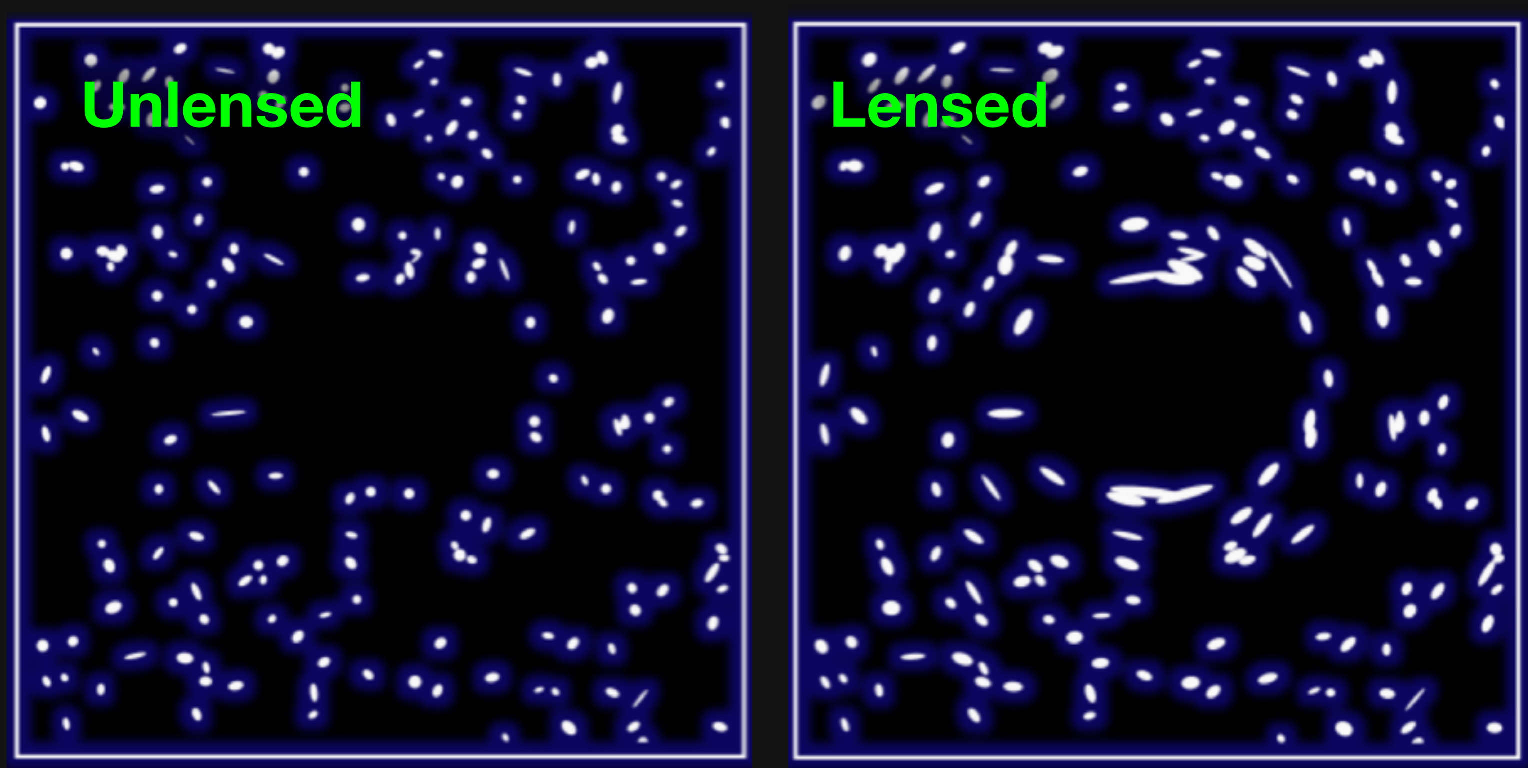
Abstract

The SKA will enable weak lensing surveys in the radio continuum regime, promising the study of large-scale structure at intermediate (z ~ 1-3) redshifts. An astrophysical systematic uncertainty in such measurements is the intrinsic alignment of galaxies, which masquerades as a genuine cosmic shear signal. The EAGLE simulation suite self-consistently evolves the dark matter and baryonic content of the universe in a cosmologically representative volume, and follows the formation and growth of galaxies over cosmic time. EAGLE's volume provides a large sample of galaxies, spanning a diverse range of environments that influence intrinsic alignment. We calculate the shapes and orientations of gas, stars and dark matter in EAGLE galaxies, as well as the alignments between neighbouring systems.

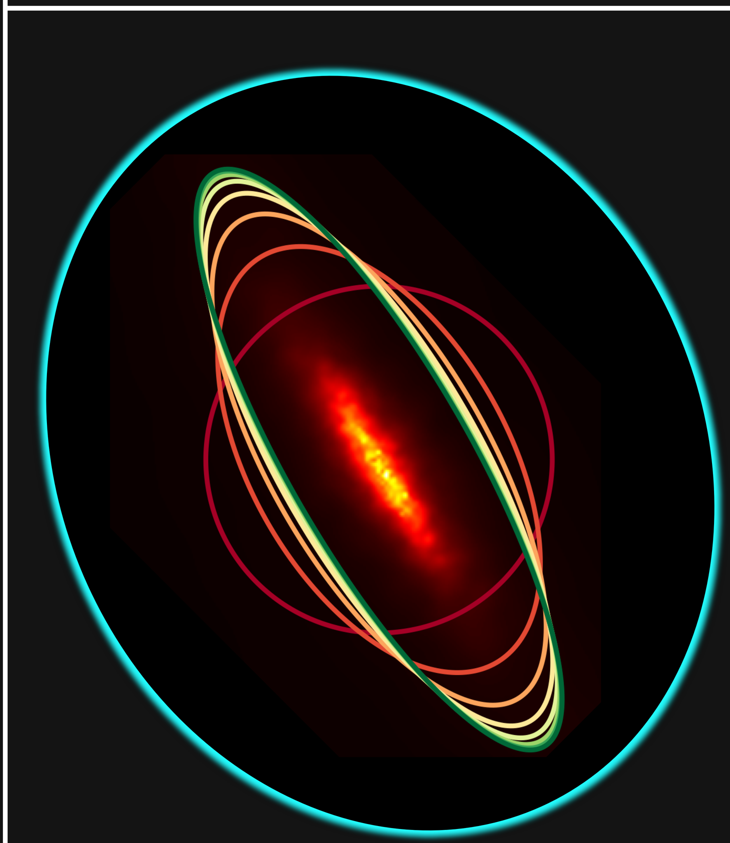
Background

- In **weak lensing (WL)**, the images of distant galaxies are coherently distorted by large-scale structure. The distortion at a given patch of sky is called the **cosmic shear**.
- This can create a non-vanishing correlation between galaxy orientations, and is used to probe many open questions in cosmology (e.g. the nature of the dark sector, the total distribution of matter in the universe).



- Tidal gravitational forces cause an **intrinsic alignment** of neighbouring galaxies, and if unaccounted for acts as a nuisance parameter in cosmic shear measurements.
- The SKA telescope will detect WL in galactic **radio-continuum emission**, emitted by the regions of **star-forming gas (SFG)** in a galaxy. [3]
- We use EAGLE to find the 3D shapes and orientations of stars, dark matter and star-forming gas, determining which observable best traces the underlying dark matter distribution, and assessing the potential strength of the intrinsic alignment signal in radio and optical surveys.

The EAGLE Project & Methodology



The iterative reduced inertia tensor in practice

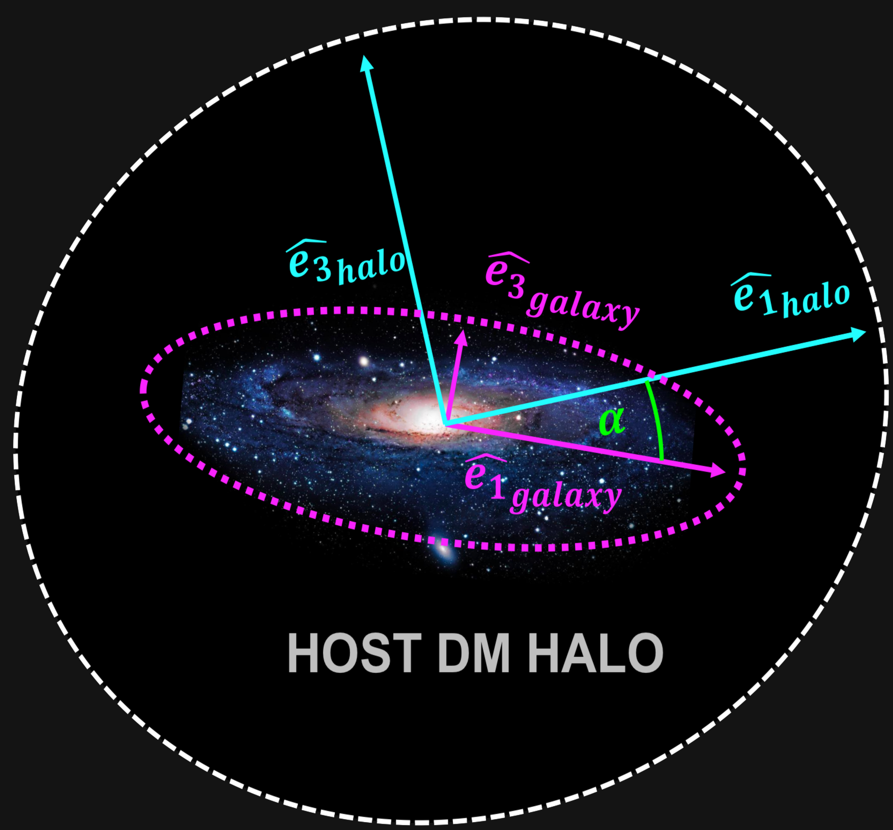
- A suite of hydrodynamical simulations that models how galaxies form and evolve over cosmic time
- Largest simulation is 100cMpc per side and contains 7 billion particles
- Following [1], we iteratively compute the reduced inertia tensor (Eq 1) to find the best fitting ellipsoidal shapes and orientations to matter distributions.
- This tensor provides the orientations and structural axes of the ellipsoid.

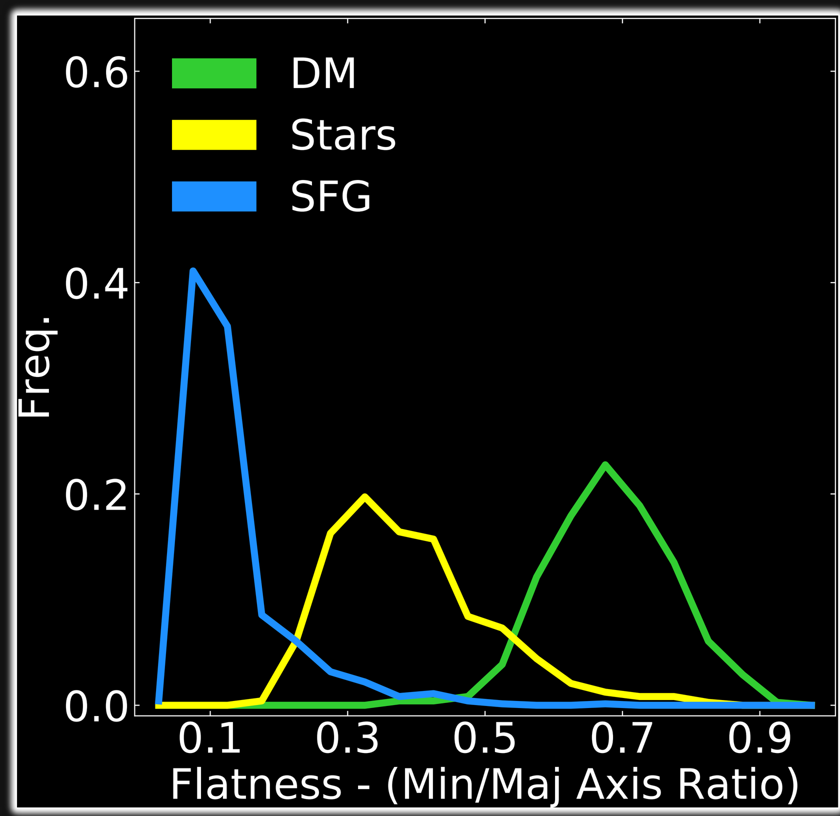
$$I = \sum_{p=1}^{N_p} \frac{m_p}{r_p^2} r_{p,i} r_{p,j}. \qquad (1)$$

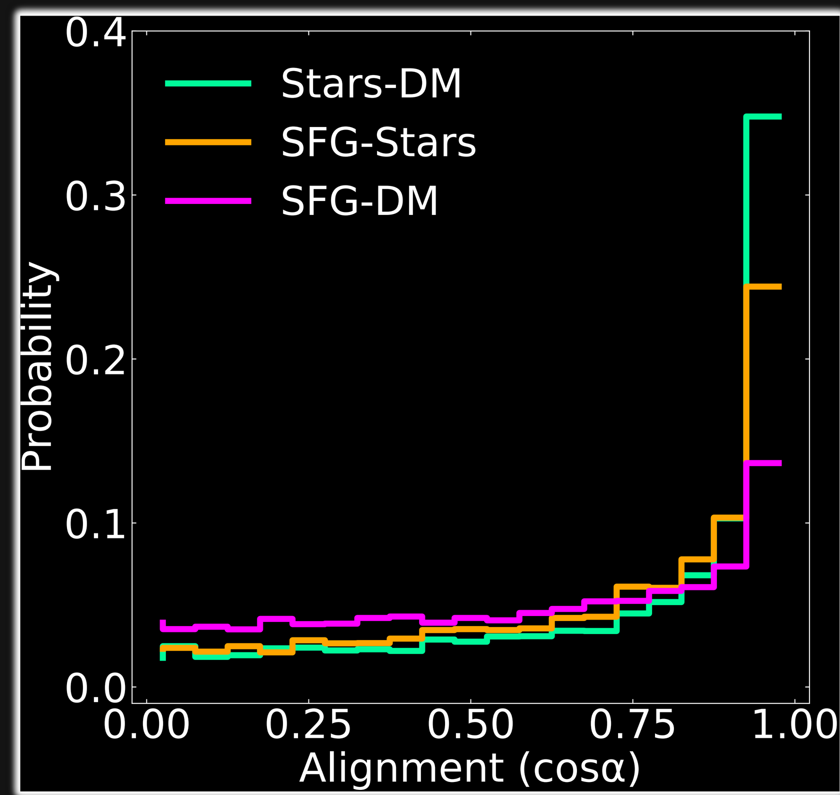
Internal & External Galaxy Alignments

Internal

While galaxies reside at the centre of dark matter haloes, they do not necessarily share their shape and orientation. We therefore first measure the shapes of the dark matter, stars and star-forming gas within galaxies.



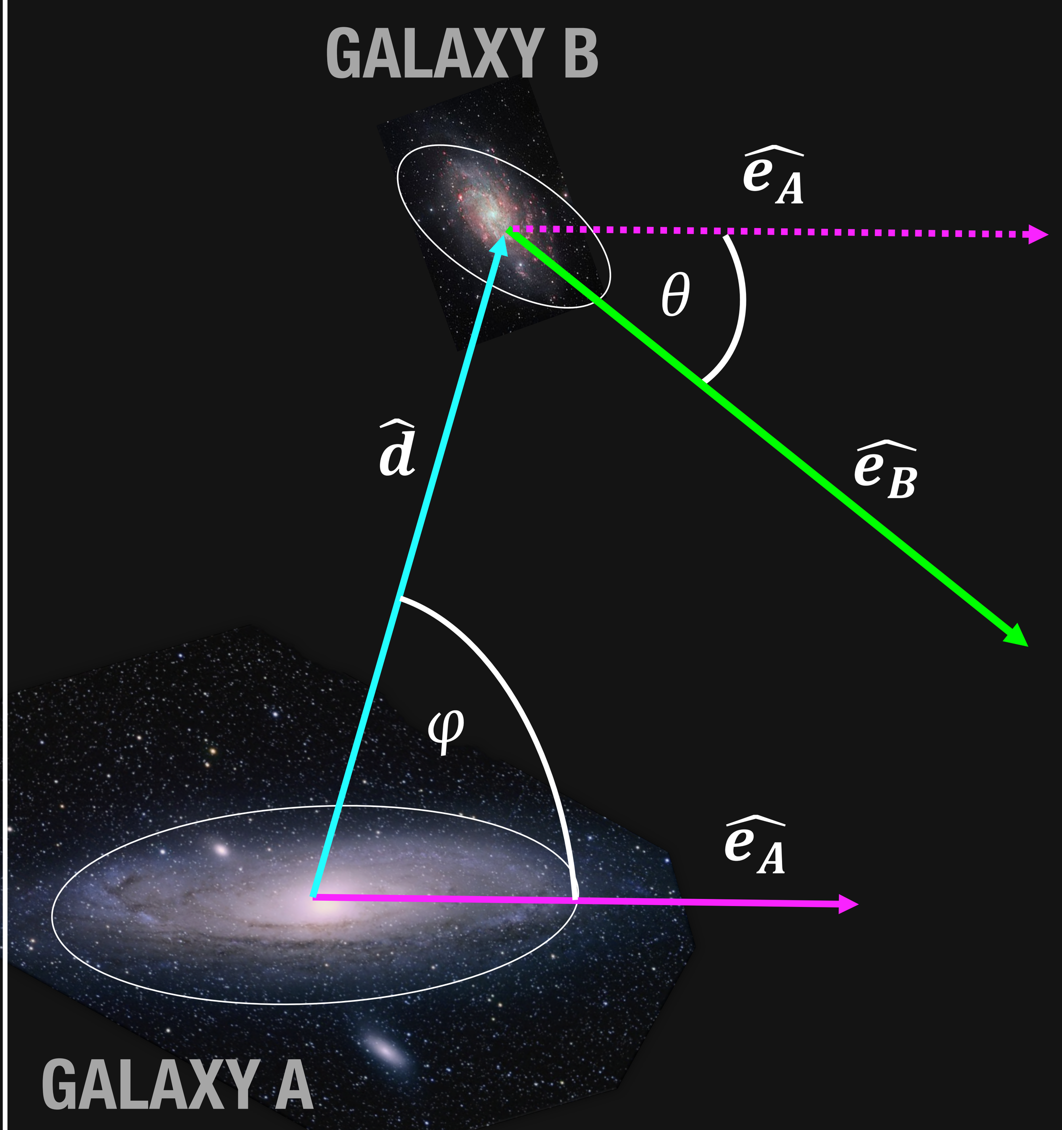


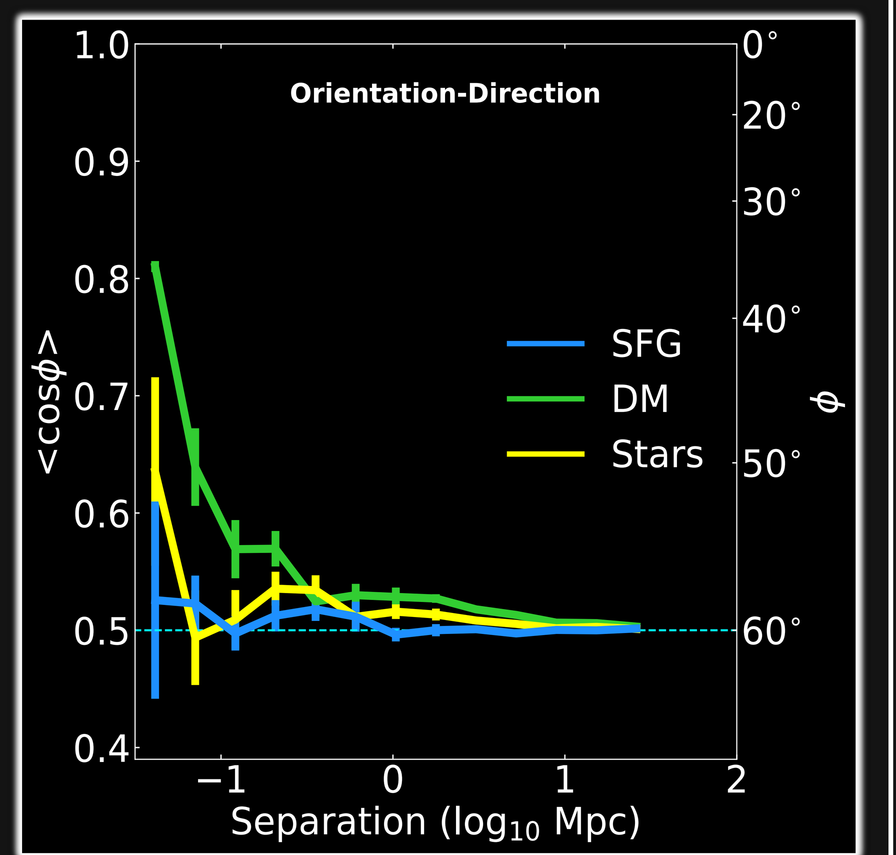


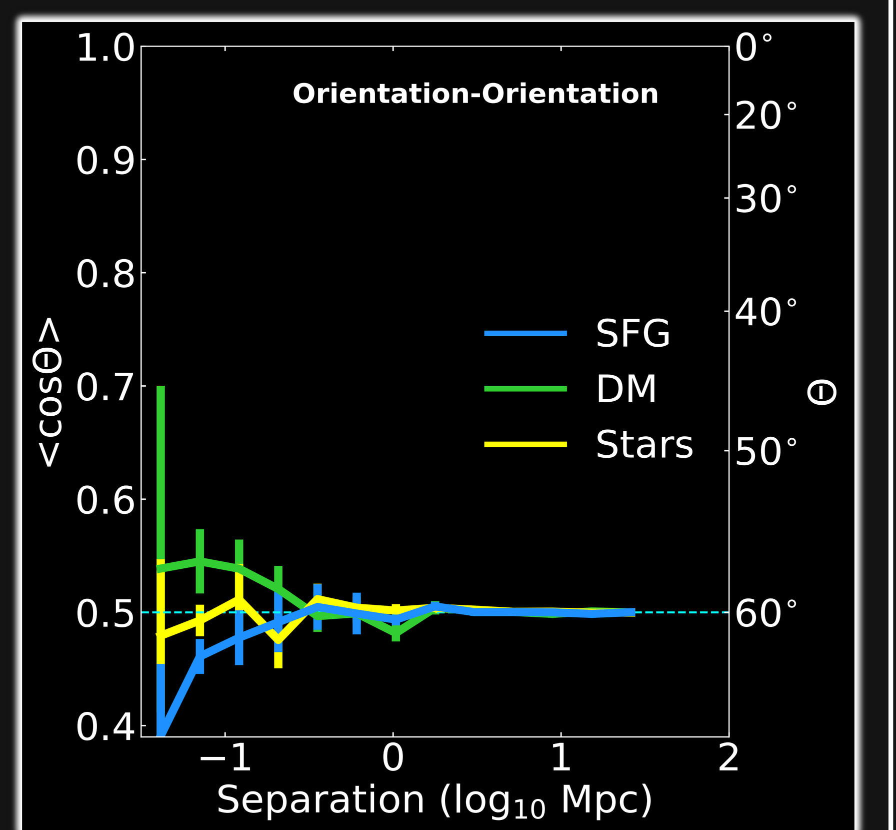
The star-forming gas, and hence the radio component, of galaxies is a poorer tracer of the dark matter distribution than stars (the optical component) in terms of morphology and orientation.

External

We measure the alignment of galaxies in order to asses the systematics affecting weak lensing measurements. We do this for the dark matter, stars and star-forming gas. φ is the Orientation-Direction Alignment, θ is the Orientation-Orientation Alignment.







The intrinsic alignment of star-forming gas distributions is lower than that of the stars, implying that radio weak lensing surveys will be less systematically affected by the intrinsic alignment of galaxies than their optical counterparts.

REFERENCES: [1] Bett. P., MNRAS, (2012), 420, 3303-3323. [2] Scahye. J., Crain. R., et al. MNRAS, (2015), 446, 521-554. [3] Brown, M., et al., PoS(AASKA14)023, (2015).
[4] EAGLE Image in Header - http://icc.dur.ac.uk/Eagle/highreader.php?page=evo [5] Velliscig, M., et al. MNRAS, (2015), Vol 545, 3328-3340.

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