1 Project description

Studying cosmic voids and dark matter via Doppler lensing

Context Cosmic voids on the scales of about ten to a few tens of megaparsecs, that are surrounded by filaments and clusters of galaxies, are by definition difficult to study, since they mostly consist of the absence of easily detectable matter rather than its presence. Dark matter — which constitutes about 80% of the matter density of the Universe according to the standard interpretation of astronomical observations — has so far not been detected directly either. However, recent nonlinear general-relativistic analytical calculations of the effects of voids on the paths of photons revealed a new effect, Doppler lensing, in which the angular sizes and apparent magnitudes of galaxies near the edges of voids are modified depending on whether they are in front of or behind void walls (Bolejko et al., 2013; Bacon et al., 2014).

Aim The primary aim is to study the viability of studying the underdensity profiles of voids and the density profiles of the dark matter haloes of galaxies in the filaments and clusters of the cosmic web by using Doppler lensing and related effects. A supplementary aim would be to apply this to the latest major galaxy surveys.

Method The new research field of general-relativistic cosmology simulation methods (INHOMOG, SIMSILUN, EINSTEIN TOOLKIT, GEVOLUTION, GRAMSES) has very recently emerged. This project would check the existing analytical formalisms against at least one of the simulation methods, such as GEVOLUTION. By using the power of full computer simulations, observational predictions would be able to be made in a way that bypasses some of the simplifications of the analytical methods. In the extended part of the project, observational galaxy catalogues would be analysed in comparison to the simulations.

Expected impact The underdensity profiles of voids and the overdensity profiles of the filaments and clusters separating the voids would be measured to higher accuracy than by previous techniques, based on linear perturbation theory. Improved constraints on dark matter models, such as the warm dark matter, interacting and decaying dark matter models, would be obtained.

References

Bolejko, K., Clarkson, C., Maartens, R., et al. 2013, *Antilensing: The Bright Side of Voids*, Physical Review Letters, **110**, 021302, [arXiv:1209.3142]

Bacon, D. J., Andrianomena, S., Clarkson, C., Bolejko, K., & Maartens, R. 2014, *Cosmology with Doppler lensing*, MNRAS, **443**, 1900, [arXiv:1401.3694]