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Testing the Cosmological Principle

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The dipolar anisotropy of the CMB is believed to be due to our motion with respect to the CMB rest frame at 369 km/s. This should cause a dipolar modulation in the number counts of distant sources, through special relativistic aberration and Doppler boosting effects. We construct an all-sky catalogue of ˜60000 radio galaxies, by combining the NRAO VLA Sky Survey (NVSS) and Sydney University Molonglo Sky Survey (SUMSS) catalogues and find a significantly larger dipole than expected, in the same direction but with a velocity of 1355 +/- 174 km/s, in tension with the kinematic interpretation of the CMB dipole at 2.81σ. As the significance is limited by shot noise due to a catalogue of finite size, we examine a catalogue of ˜2.4 million galaxies, observed by the Widefield Infrared Survey Explorer (WISE) satellite. After suppressing star contamination and sources at low redshift through innovative use of apparent motion fits and photometry, the dipole in the remaining ˜1.2 million sources converges in direction to the CMB dipole, while still favoring a velocity higher than ˜1000 km/s. This dipole can be reconciled with the CMB dipole only for a non-Copernican observer situated within a bulk flow greater than 240 km/s on scales exceeding 100 Mpc, which is unexpected in a LambdaCDM universe at a level less than 3%. The deceleration parameter q0 derived from local observations is then expected to show a scale-dependent dipolar modulation. From a maximum likelihood analysis of the Joint Lightcurve Analysis (JLA) catalogue of Type Ia supernovae we do find such a dipole in q0 extending out to z~0.2, with a magnitude comparable to its monopole. Although not statistically significant in current data, such a dipole must be allowed for, especially in analysing surveys with incomplete sky coverage such as JLA and its successor Pantheon; out of 740 (1048) SNe IA in the JLA (Pantheon) catalogue, 632 (890) are in the hemisphere opposite to the direction of bulk flow for which their redshifts have been corrected. However when we do so, the monopole component of q0, which has been widely ascribed to a cosmological constant (dark energy), drops in statistical significance and becomes consistent with zero at 2σ (95\% c.l.). This suggests that the apparent acceleration of the expansion rate deduced from supernovae may be an artifact of our bulk flow.

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