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# Scattered and Stellar Light in Very Distant Radio Galaxies and Updates on a Test of the Einstein Equivalence Principle

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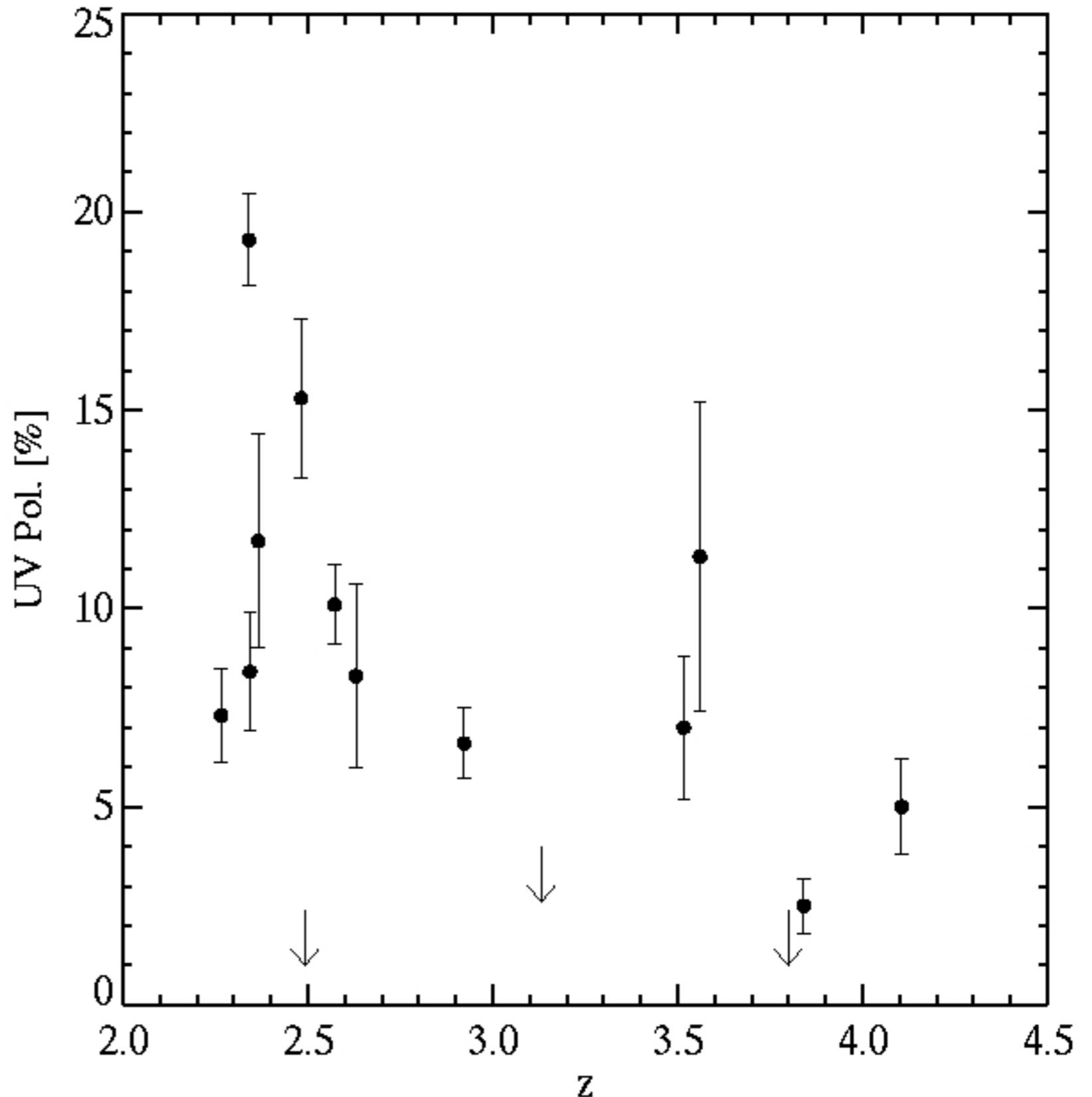
with C. de Breuck, J. Vernet, A. Cimatti, G. Miley, W. van Breugel



# The linear polarization of powerful radio galaxies with $z > 2$

The optical/UV polarization of powerful radio galaxies is due to **scattering of anisotropic quasar radiation** from the nucleus (see the review by Clive Tadhunter 2005, ASP Conf. Ser., Vol. 343, p. 457).

Recent efforts have concentrated on RG with  $z > 2$  and seem to show a lack of highly polarized objects with  $z > 2.5$  (De Breuck et al., in prep.), possibly due to **increasing dilution by young stars**, as suggested also by the anticorrelation between UV polarization and submillimeter flux (Reuland et al. 2004) and by the emission line ratios and Spitzer fluxes (Villar Martin et al., in prep.).



# The Einstein Equivalence Principle (EEP)

The equivalence principle equates a **gravitational field** and a **uniformly accelerated frame**, and is the foundation of the idea that spacetime is curved. It comes in three forms:

1. the weak equivalence principle (WEP) stating the equivalence as far as **the motion of free falling bodies** is concerned.
2. The EEP extends the equivalence to **all experiments involving non-gravitational forces**; all metric theories of gravity are based on the EEP.
3. The strong equivalence principle (SEP) extending the EEP **also to gravitational experiments**.

The WEP is tested to an accuracy of  $4 \times 10^{-13}$  by Eötvös type (torsion-balance) experiments, while the EEP is tested to an accuracy of only  $\sim 10^{-4}$  by gravitational redshift experiments.

In 1960 Schiff has conjectured that any complete, self-consistent theory of gravity which obeys the WEP would necessarily obey also the EEP.

However Ni (1977) has found a unique counterexample to Schiff's conjecture: a pseudoscalar field  $\Phi$  that couples to electromagnetism in a Lagrangian of the form:

$$L = 1/16\pi \sqrt{g} \Phi e^{\mu\nu\rho\sigma} F_{\mu\nu} F_{\rho\sigma}$$

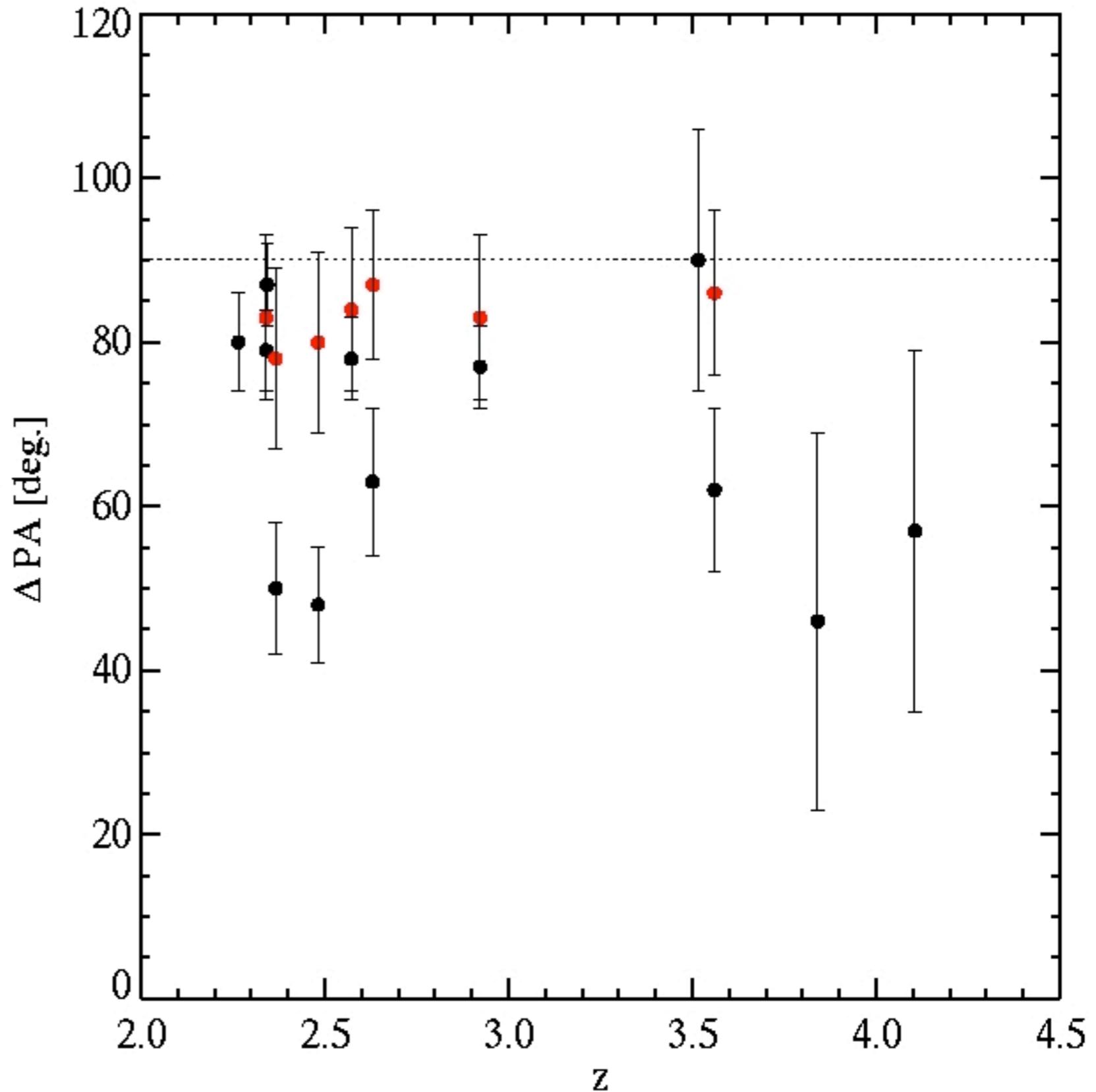
leading to a violation of the EEP, while obeying the WEP.

Carroll & Field (1991) have shown that, if such coupling were significant in a cosmological context, then the plane of polarization of light coming from very distant objects would be rotated during its journey across a considerable fraction of the size of the Universe. **If we could show that such a rotation is not observed, we would then conclude that the EEP is not violated in this unique fashion.**

# Testing the EEP with high redshift radio galaxies

Cimatti et al. 1994 have shown that the perpendicularity between the optical polarization angle and the optical/radio axis holds within  $10^\circ$  for every single radio galaxy at  $z \sim 1$  with a polarization measurement. This perpendicularity is clearly predicted by the scattering model which is a direct consequence of the RG/QSO unification.

Here I update and extend this test to higher redshifts ( $2 < z < 4$ ) using all radio galaxies with a polarization measurement. The perpendicularity of the polarization angle is better with the UV axis (red points) than with the radio axis (black points), as foreseen by the scattering model, because of disuniformities in the distribution of the scatterers and of possible bends in the radio jet.



# Summary

- We have presented new rest-frame UV polarization measurements for 4 powerful radio galaxies with  $z > 3$ , and reviewed all measurements for  $z > 2$ .
- There appears to be a lack of highly polarized radio galaxies with  $z > 2.5$ , possibly due to the increasing dilution by young stars, in agreement with current estimates of the formation redshift of massive ellipticals.
- The perpendicularity between the polarization angle and the UV/radio axis up to the highest redshifts provides the most stringent test of the Einstein equivalence principle.

