Abstract

In two recent papers, Abramowicz et al. claim that the expansion of the Universe can be interpreted only as the expansion of space. In fact, what they really prove is that the cosmological expansion cannot be described in terms of real motions in Minkowski spacetime. However, there is no controversy about this issue. Abramowicz et al. show that in general, the cosmological redshift is not a Doppler shift and they consider this fact as a proof that space expands. Again, nobody believes (perhaps except Milne) that for non-empty universes the origin of the redshift is purely Dopplerian. From the Principle of Equivalence it follows that there must be also a gravitational shift in presence of matter. Indeed, it is well known in cosmology that for small redshifts, the cosmological redshift can be decomposed into a Doppler component and a gravitational component. In a forthcoming paper, we shall perform such a decomposition for arbitrarily large values of the redshift.

1 Introduction

Erroneous identification of Special Relativity (SR) with ‘real motions’, and General Relativity (GR) with the ‘expansion of space’ has a long history in cosmology. This misconception dates back to Milne (1933) (see Chodorowski 2007 for a discussion). Unfortunately, it has been inherited and is shared by many contemporary authors, including Abramowicz et al. (2007, 2008). They show that Friedman-Lemaître cosmological models are not (except for the empty model) compatible with SR, and use this fact as an argument for the expansion of space. Many other facts and gedanken experiments have been presented as a proof for the expansion of space, but thus far, they have been all abolished (see Chodorowski 2007 for a description and references; Lewis et al. 2008).

Obviously, defenders of the idea of real motions have a hard time, because, as pointed out by Popper, you cannot prove a theory; you can only falsify it. However, there is a long (and good) tradition in science that faith in a given theory is proportional to the number of failed attempts to disprove it. We hope that this will be also the case for the idea of real motions. Personally, however, we have no longer patience to be actively involved in the subject. Let others do it. Indeed, there are recent papers on this issue (Lewis et al. 2008, Bunn and Hogg 2008), with similar conclusions to ours.
Bunn and Hogg show that in ‘some sense’ the cosmological redshift is a Doppler shift. We don’t think that this particular ‘sense’ is the best one, but their paper suggests an interesting way of decomposing the cosmological redshift into a Doppler component and a gravitational component, for any value of the redshift. It is well known how to do this for small redshifts (e.g. Bondi 1947, Peacock 1999), but not for large redshifts. There have been some attempts to do this in the past (Infeld and Schild 1945, Fock 1955), but for reasons we will describe elsewhere, they were not successful. In a forthcoming paper, using fully generally-relativistic approach we perform such a decomposition for arbitrary redshifts. In the limit of small redshifts, our result reduces to the well-known second-order formula.

Our Universe is in fact inhomogeneous: fluctuations of matter and radiation are present (though small) even on the largest scales. How to describe this fact in terms of expanding space? Does space expand at a different rate in different points? Still, the concept of expanding space seems to be a useful teaching aid to visualize uniform expansion. You take a balloon. You draw dots on its surface. You tell students that the dots represent galaxies. You blow up the balloon. Distances between points increase. Students are fully convinced that galaxies really remain in rest (by the way, relative to what?) and this is the expansion of space that causes them to separate. Simple? Simple. But in reality, the balloon does not exist; there are only dots. GR is a classical theory. As such, it describes motions of relativistically moving massive bodies in presence of gravity. The concept of spacetime is central in this theory, but endowing space with physical properties is incorrect.

Finally, let us quote Steven Weinberg (1993). ‘(...) space does not expand. Cosmologists sometimes talk about expanding space – but they should know better.’

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