

Intrinsic redshift in quasars

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A recent paper by MRS Hawkins “On time dilation in quasar light curves” [2] conclusively proves that quasars have intrinsic redshift.

[83C57](#); [85A40](#), [83F05](#)

Introduction

At first sight, a recent paper by MRS Hawkins [2] exhibits a paradoxical phenomenon namely redshift without time dilation. The paradox comes from the fact that redshift and time dilation are effectively identical in general relativity. The redshift z of an emitter trajectory as seen by a receiver trajectory is given by

$$(1) \quad 1 + z = \frac{dt_r}{dt_e}$$

for the 1-parameter family of null geodesics connecting the emitter to the receiver in the forward direction, where t_e and t_r are proper time along the emitter and receiver trajectories respectively.

On the other hand the observed (instantaneous) time dilation is also (by definition) given by $\frac{dt_r}{dt_e}$ for the same family of null geodesics and it follows that if a radiation source exhibits redshift then it also exhibits the correctly correlated time dilation.

It is important to stress that *this fact is an elementary consequence of the space-time geometry underlying General Relativity and has no dependence whatsoever on cosmological assumptions*. It is equally true in an expanding universe and in a static or contracting or chaotic universe and it is true whatever the cause of the redshift whether Doppler or gravitational or due to changes in the geometry of space-time or any other relativistic effect. It is also true in any conceivable variant of general relativity. Any theory based on space-time with well-defined light paths will have this property. I stress this because the discussion in the paper makes it quite clear that this utterly fundamental point has escaped the author. To flog this dead horse further you can see intuitively that the two coincide by noticing that redshift simply measures the time dilation between successive energy peaks of an electromagnetic wave and that any other way of measuring time dilation also measures the same dilation for some other series of events.

The Hawkins result

Hawkins examines a large pool of observations of quasars. Quasars radiate electromagnetic waves and this radiation varies in intensity periodically over macroscopic time intervals from days to years. He makes a very careful selection from the pool (some more detail on this will be given later) and uses some very sophisticated analysis (which seems sound) to find a collection of quasars for which the macroscopic intensity variation does not exhibit time dilation correlated correctly with the observed redshift; indeed for this selection, the high redshift and the low redshift bins exhibit on average *exactly the same time dilation*. For full details, see [2].

This result is not paradoxical. What it shows is that for this selection of quasars the sources of

(a) the radiation

and

(b) the time variation

are not in the same place. To enable discussion let us call these the *generator* and the *modulator* respectively. Before continuing it is worth quickly summarising the four possible explanations that Hawkins proposes. They are:

- (1) black hole growth
- (2) microlensing (this term is explained below)
- (3) static universe
- (4) intrinsic redshift.

Of these (1) and (3) can be immediately discarded because they both propose a relativistic explanation, which as we have seen cannot cover a dichotomy between redshift and time dilation. The other two are viable possibilities and to explain these we need at this point to consider the possible arrangements for the generator and modulator.

The intrinsic redshift arrangement

It is commonly accepted that the generator of a quasar is a compact highly massive object usually called a “black hole” and that the radiation comes from an excited layer of matter close to the hole.

There is no similar consensus for the modulator. But for active galaxies there is a consensus view that there is again a central black hole and that this is surrounded by a rotating accretion disc and other structures. Quasars and active galaxies are part of

a spectrum of phenomena associated with black holes and therefore that the central black hole in a quasar should be surrounded by similar rotating accretion structures. These might comprise strata of gas or plasma close to the centre and further out more solid objects, all of which will typically be trapped in orbit around the central mass. The radiation from the generator passes through these surrounding layers on its way to us; the observed variations are due to non uniformity in these layers, and are naturally periodic with the possibility of several different periods coming from different layers superimposed. This is what is actually observed.

We now have a very natural model for the modulator and a natural explanation for the Hawkins result. The generator is subject to gravitational redshift because of the black hole nearby and the modulator being some distance away is not subject to the same redshift and this explains the dichotomy between redshift in the generator and time dilation in the modulator.

Because of the gravitational redshift the the quasar is closer (and less luminous) than would be the case if the redshift were entirely cosmological. The usual name for this phenomenon is *intrinsic redshift* and it has a famous champion in Halton Arp [1].

The microlensing arrangement

It is clear that the modulator must be on the light path from the generator to us. It does not need to be directly associated with the generator, as in the intrinsic redshift arrangement discussed above, anywhere on the path will do, provided it lies in a region of low cosmological time dilation. One way variations in intensity could arise would be if the path were subject to variable gravitational lensing effects or passing through a region of variable density. Both of these phenomena are called *microlensing*. There are indeed cases where this is known to happen (see eg Schild et al [5]) and if this happened to a large proportion of quasars then it would also explain the Hawkins result.

But is this plausible? It's not the existence of microlensing that is at doubt but its pervasiveness. It would be necessary to assume that there is a microlensing region happening to lie on the light path from *most quasars to us* and *close to us* as well. This is highly implausible unless nearly all space acts a microlensing region, eg if it is filled with suitable gravitational waves. There is indeed evidence for a gravitational wave field affecting distant observations, see [3], but if this background field were strong enough to account for observed quasar variation then everything distant would have similar patterns of variation and no such variation has been observed for distant galaxies.

The only other way this could work would be if quasars were defined by the existence of a suitable microlensing region on the path to us. In other words if quasars were in fact

distorted images of distant galaxies. But this possibility is again implausible because quasars have quite different radiation characteristics which could not be disguised by microlensing. So although apparently suitable as an explanation for the Hawkins result, microlensing has to be discarded.

Proof of intrinsic redshift

The Hawkins result implies that, for a large class of quasars, the generator and the modulator are some distance apart with the modulator in a region of low cosmological redshift. The modulator must lie on the light path from the generator to us. There are only two possibilities: it lies close to the generator, which therefore has intrinsic redshift, or, it lies on the path to us and close enough to us for the cosmological redshift to be small. As we have just seen, this second possibility is implausible, and intrinsic redshift is proved.

Sample selection

Finally we turn to a basic question. For any random sample of objects in the universe (which we now assume to be the standard expanding universe of current cosmology) there should be a correlation between redshift and time dilation whatever the mechanism that produces these locally. This is because the more distant objects will have both higher redshift, with the addition of cosmological redshift, and higher time dilation for the same reason. Hawkins has managed to find a sample which does not have this property. Obviously he must have used a non-random selection criterion at some point. And indeed he has. In an attempt to avoid the effect of another well-known correlation, between magnitude and redshift in limited samples (see below) he has limited his sample to a very small magnitude range namely between magnitudes -25.5 and -22.5 . This narrow sample contains high redshift quasars which have low luminosity and are close to us, and low redshift quasars with high luminosity which are distant. The former, being close to us, are subject to small cosmological time dilation effects and the latter to large ones. Thus the redshift–time dilation relation is skewed against the natural cosmological relation by the presence of these quasars whose redshift–time dilation is opposite to the natural relation, and this accounts for the redshifts in the sample not having the expected correlation with time dilation.

Remarks

In passing, it is worth remarking that the well-known correlation (between magnitude and redshift in flux limited samples) mentioned above is probably due to observer

selection bias. Most quasars are probably based around quite small black holes and the nearby ones (ie the ones with greatest magnitudes) will be the easiest to detect. The flux limitation eliminates then nearby ones with low redshift and very high magnitude. Thus in any given flux limited sample, the higher magnitude quasars are more likely to be the nearby ones with high redshift.

There is also another very interesting result that is proved by the Hawkins paper. There is an anti-correlation between luminosity and amplitude for the quasars in the sample. The more luminous, the smaller the range of variation. Again this is likely to be due to selection bias. Suppose that the quasars in the sample have roughly the same basic luminosity (ie if there were no masking effects). Then the higher the observed luminosity the thinner the masking layers. Thinner masking layers cause lower amplitude variation.

Finally I refer you to my joint paper with Rosemberg Toala Enriques and Robert MacKay [4] which constructs a model for quasar radiation which has all the properties mentioned above.

Conclusion

This is a quite remarkable and very important paper but not for the reasons that the author states. He has managed to select exactly a perfect sample of quasars which has redshift variation not correlated with time dilation. As we have seen this conclusively proves that intrinsic redshift is found in quasars. If he had set out with the intention of proving this, he could not have managed it better.

References

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