Astronomy

An extraordinary gravitational lens and the redshift debate

from M. G. Edmunds

ONCE in a while a remarkable astronomical object is found in a fairly routine observing programme. Just such an object turned up last September during a galaxy redshift survey by the Harvard-Smithsonian Center for Astrophysics. The first published set of observations (Huchra, J. *et al.* *Astr. J.* **90**, 691; 1985) shows that right in the centre of an unremarkable redshift ($z=0.04$) spiral galaxy there sits the image of a high redshift ($z=1.7$) quasar.

There is no doubt that the quasar is of high redshift — the spectrum is almost a textbook example, showing strong hydrogen Lyman α and carbon-ion emission lines. The brightness and size of the galaxy (known by its positional coordinates as 2237+0305) are perfectly consistent with its low redshift. Yet the quasar is within about one-third of an arc of the centre, as judged on images recorded by a charged couple device solid-state detector when the terrestrial atmospheric seeing conditions were smearing point images to about two seconds of arc in size.

It is fascinating to speculate how the debate over the origin of quasar redshifts would have been affected if this object had been discovered twenty years ago, but it is unlikely that current theories of the non-cosmological origin for redshifts will have to be resurrected. Many cases are known of bright nuclei in galaxies that show quasar-like spectra (the so-called Seyfert galaxies) but whose redshifts (and by implication, distance) are the same as the host galaxy. The new object can probably be interpreted as a distant quasar, the image of which is brought towards us by the gravitational field of the nearby galaxy acting as a lens. The detection of the first gravitational lens (other than the classic deflection of light by the Sun) was reported in *Nature* in 1979 although they had been predicted by Einstein and championed by Zwicky in the 1930s. Five good cases of gravitational lensing of distant quasars are already known (for example, Turner, E.J., Ostriker, J.P. & Gott, J.R. *Astrophys. J.* **284**, 1; 1984), but these differ from 2237+0305 in that the galaxies causing the lensing are much more distant and they produce at least double quasar images.

The fun really starts when an attempt is made to estimate how likely it is that we should be able to find a system like 2237+0305. The assessment of *a posteriori* probabilities for a single object is, of course, a very subjective and uncertain task. Nevertheless, it is clear that this is a very unusual system. The chance of find-

ing such a bright quasar (approximately 17th blue magnitude) within an arc second of the centre of galaxies that have been spectroscopically surveyed would be only about one in ten thousand but, as with a conventional lens, the gravitational lens can not only bend light but also brighten the image. The difficulty, as pointed out by Huchra *et al.*, lies in the fairly large amplification factor that probably has to be invoked to increase the chance of finding such an object to, say, the few per cent level. If the quasar is not amplified, its intrinsic brightness (as implied by its redshift) must be unusually large.

Huchra *et al.* suggest that an amplification factor of 40 would give a reasonable probability of detection, and they claim that they can construct a lens model in which the required mass-to-light ratio of the galaxy is not unreasonably high (21 in solar units). But they neglect two factors in their revised probability estimate. The first is to fold into the estimate the probability of having a lens configuration that will produce such a high amplification; the configuration cannot be particularly common, since only very restricted conditions give high light amplification. The second problem is the effect of absorption by in-

terstellar matter in the galaxy through which the quasar is seen. Huchra *et al.* note that the optical continuum spectrum of the quasar appears to be highly reddened, showing a power law dependence on frequency of $\nu^{-3.5}$, compared with a typical $\nu^{-0.6}$ for most quasars. While it is possible that the object has an intrinsically steep spectrum, it is not difficult to show that the change in continuum slope from a typical value implies three magnitudes of extinction and hence requires yet another factor of 20 in amplification of the background object.

These two problems seem to make the detection probability dwindle too much for comfort, but it would be wise to wait for more detailed lens models and further observations before passing judgement. Higher spectral resolution observations reveal whether the quasar shows any sign of interstellar absorption features, such as calcium H and K lines and the sodium D line, which would give an independent estimate of extinction. Observations at deeper and higher spatial resolution, which will require seeing conditions of about half an arc second, may resolve the central image into subsidiary images which would allow better modelling of the lensing. The lensing explanation would, of course, be established were spectroscopic evidence that each of the split components had the same redshift to become available — an excellent project for the Space Telescope when it is launched. □

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Protein structure

A new twist for hairpin turns

from Jane S. Richardson

IN protein conformation, the tight turn^{1,2} is considered the classic, neat solution for connecting two antiparallel strands of beta-sheet. However, in the course of surveying and cataloguing short beta-hairpin connections (see page 170 of this issue³), Lynn Sibanda and Janet Thornton have unexpectedly found that this apparently obvious combination is not so well matched after all.

Beginning with the chiral alpha-carbons of natural L-amino acids, conformational features at all levels of protein structure show strong handedness preferences such as the right-handed alpha-helix, the right-handed twist of beta-sheet (see figure and ref. 4), and the right-handedness of beta-alpha-beta crossover connections^{5,6}. Tight turns also have a handedness, as they are not really planar as often drawn but have a pronounced dihedral angle defined by the four successive alpha-carbons. In the most common turn, termed Type I, that dihedral angle is approximately -45° (ref. 7). There is a mirror-image version of the

Type I turn (called Type I') which has a $+45^\circ$ dihedral angle, but it is very rare because it puts the side-chain beta-carbons uncomfortably close to the backbone and so only works well with glycine.

Sibanda and Thornton⁷ now show conformational preferences for each size category of beta-hairpins. For the shortest hairpins (with only two residues connecting the last hydrogen-bonded pair in the beta-strands) they find only 4 Type I turns but 15 Type I'. This is quite startling, as it reverses the overall occurrence statistics by a factor of about 40. The unusual circumstance responsible for that reversal is presumably a strong interaction between the twist of the beta-sheet and the twist of the turn. Those twists match perfectly for Type I' but fight each other for Type I, as illustrated in the figure.

One can imagine this built-in conflict as resolvable in two distinct ways during the folding of a real protein structure. If a beta-hairpin initially formed with its turn in the standard Type I geometry, the beta-