A Common Proper Motion Companion to the Exoplanet Host 51 Pegasi

John Greaves

Northampton, U.K.

Abstract: The exoplanet 51 Pegasi has a widely separated red dwarf companion. Two other, far more distant, stars are also co-moving with this star, showing that they are at least of common Galactic orbit due to a common origin.

Introduction

The somewhat Sun-like nearby G dwarf star 51 Pegasi was shown to be host to a substellar companion, or "exoplanet", ten years ago (Mayor and Queloz 1995), the exoplanet being estimated as a roughly half Jovian mass object orbiting the G star roughly every 4.2 days at a distance of 0.05 Astronomical Units (AU).

Proper motion data shows that this high proper motion star is not moving alone in space, with at least one if not three distant co-moving companions.

The Nearer Comoving Star

The Hipparcos Catalog (ESA 1997) shows that the proper motion of 51 Pegasi is 208 milliarcseconds per year (masy^{-1}) in Right Ascension (RA), with the correction made for the cosine of the Declination, and 61 masy^{-1} in Declination (Dec) with errors <1 masy^{-1}.

The UCAC2 (Zacharias *et al* 2004) reveals a star at J2000 coordinates RA 23h00m33.8s and Dec +21° 35' 22" with proper motion of 200 masy^{-1} in RA and 66 masy^{-1} in Dec with errors <1 masy^{-1}. The star is NLTT 55547 (Luyten 1979).

The separation amounts to 3942 arcseconds (~ 1.1°) in a position angle of 41 degrees. Such a distance is somewhat large, however 51 Pegasi is a fairly nearby star, lying roughly 15 parsecs distant, with a parallax of 65.1 ± 0.8 milliarcsecs according to Hipparcos (ESA 1997). This angular separation at that distance gives a projected true separation of 0.3 parsecs (very nearly 1 "light year") which in turn would lead to an orbital period of roughly 14 million years in the circumstance where the projected true separation was comparable to the semimajor axis, and given a reasonable combined mass for 51 Pegasi and this red dwarf companion of 1.2 M_o or thereabouts. Such an orbital period is unlikely, and the pair are probably not gravitationally connected.

That the companion is a red dwarf is shown by combining the V 15.61 given by Salim and Gould (2004) with the 2MASS J magnitude of 11.96 and K_s magnitude of 11.11 (Cutri *et al* 2003) to give J-K_s of 0.85 plus V-K_s of 4.50 (taking the reasonable assumption of negligible difference between 2MASS Ks and various other K bands, see Cutri *et al* 2003 again) and using Figure 2 of Bessell and Brett (1988) to see that these values lie well along and within the branch of objects that are defined within that article's text as delineating the red dwarfs.

This V magnitude of 15.61 equates to an absolute magnitude, M_V, of 14.7, taking the viewpoint that as this star is truly a companion to 51 Pegasi which means it should be more or less at the same distance of 15.3 parsecs, and this absolute magnitude value is not inappropriate for a cooler spectral class M dwarf. The star is therefore displaying similar motion in two dimensions and of a similar distance as 51 Pegasi, although ideally a trigonometric parallax to check its true, as opposed to estimated, distance, or to a lesser extent a radial velocity measure to check agreement in motion for the third dimension, is necessary.

Two More Distant Comoving Stars

A wider search radius, of some ten degrees, reveals that two other stars share the motion of 51 Pegasi. These are NLTT 54064 at J2000 RA 22h31m15.3s and Dec +17° 09' 45" with proper motion RA 206 masy^{-1} and Dec 67 masy^{-1} and NLTT 54007 at J2000 RA 22h 30m 00.0s and Dec +15° 23' 48" of proper motion 202 masy^{-1} and Dec 64 masy^{-1}, all epoch

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2000. The identifiers are from Luyten (1979) and the positions and proper motions are from UCAC2 (Zacharias *et al* 2004), with the proper motion in RA being corrected for the cosine of Declination here.

This equates to 7.1° separation in position angle 240° for NLTT 54064 and 8.4° separation in position angle 230° for NLTT 54007.

As with the case of NLTT 55547, neither of these objects appear to be known in nearby star catalogues and neither do they appear to have any trigonometric parallax listed.

Using Salim and Gould (2004), 2MASS (Cutri *et al* 2003) and Figure 2 of Bessell and Brett (1988) again, NLTT 54064 and NLTT 54007 have V 13.17 and 15.04; V-K_s 4.50 and 4.35; and; J-K_s 0.85 and 0.83 respectively, also appropriate for red dwarf stars. In this instance, however, although NLTT 54007 is similar in colour and apparent magnitude to NLTT 55547 such that an assumption of two similar stars at a fairly common distance is somewhat safe, NLTT 54064 is two magnitudes brighter than both, despite being of very similar colours. There is some scatter in red dwarf absolute magnitudes with respect to colour, due to metallicity/population and mass, however this size of difference is a cause for some concern, especially as there should be no differences in metallicity and population for a co-moving group.

As with NLTT 55547, the situation would be much clarified by either trigonometric parallax measurements (preferred) or radial velocity measurements (probably adequate) of these red dwarf stars.

Conclusion

The G dwarf "hot Jupiter" hosting star 51 Pegasi appears to share the same space motion as three red dwarfs, with the high proper motion and (apparent) distance of at least two of those red dwarfs being sufficiently very close to that of 51 Pegasi to preclude coincidence, although one of the red dwarfs at first sight appears anomalously too bright to make the conclusion of a similar distance safe.

One of the three red dwarfs could be as close as 0.3 parsecs to 51 Pegasi itself, and the stars may represent a comoving group of objects formed near contemporaneously at a common source in the distant past.

Trigonometric parallax measurements are essential to confirm or refute the commonality of these stars, although radial velocity measurements may be sufficiently informative to either increase the weight of evidence for association or firmly refute any such.

If confirmed, three newly recognised nearby red dwarfs are added to the nearby star lists, whilst exoplanet hosts are put into a wider context with respect to multiplicity and/or moving groups.

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