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Type II? Cepheid Radii and TX Del

C. D. Laney

South African Astronomical Observatory, PO Box 9, Observatory 7935, Cape, South Africa

There is often some dispute in the literature as to whether a particular Cepheid (S Vul, for example) belongs to Type I or Type II. JHK photometry has been used to calculate Baade-Wesselink radii for a number of stars always, sometimes or occasionally stated to be Type II Cepheids. Radial velocities have been taken from the literature.

1. Type II Cepheids

The $(K, J-K)$ radius of **SW Tau** is 8.30 ± 0.34. This is about half of the expected radius for a Type I Cepheid at this period and normal for Type II.

For **V553 Cen**, the relative phasing of radial velocities and infrared photometry has to be done by choosing a relative phasing where the phase shift between the radius displacement curve integrated from the radial velocities and the photometric radius displacements is minimized, and where the surface brightness coefficient A (Balona 1977) is normal for a star with the colour indices of V553 Cen. Uncertainty in the reddening has a negligible effect on the radius solution obtained in this way. I have also considered the degree to which the $K, J-K$ and $K, V-K$ solutions give similar answers, as the relative phasing of the optical photometry and the radial velocities was more straightforward. The $(K, J-K)$ radius is 11.2 ± 0.4, normal for a Type II Cepheid.

For **AU Peg**, the data have been phase shifted as described for V553 Cen, but the required value is very small. Only the last 18 radial velocities in Harris, Olszewski, & Wallerstein (1984) have been used, as the phase jitter gives excessive scatter in RV_{puls} if all the available RV data are included. The $(K, J-K)$ radius obtained is about 11.8 ± 1.0, indicating that this is a BL Her star. This is as expected given the short orbital period, high galactic latitude, and IR colour excess.

For **Kappa Pav**, relative phasing is not a problem, and the $K, J-K$ and $K, V-K$ radii are very similar. The $(K, J-K)$ radius is 29.06 ± 0.85, again about half the expected radius of a Type I Cepheid of this period.

The available data strongly suggest that **AL Vir** is a binary W Vir star with a period somewhat less than 1900 days. This considerably complicates the solution, but the $(K, J-K)$ radius of 34 ± 2 allows the exclusion of any possibility that this halo object belongs to Type I.

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2. Type I Cepheids

For **T Ant**, phasing can be established from the sharp photometric temperature maximum in both JHK and optical photometry. The $(K, J-K)$ radius of 46.64 ± 1.31 is normal for a Type I Cepheid with a period of 5.9 days. Its Type II status assigned by Harris (1985) seems erroneous.

The existence of contemporaneous radial velocities and JHK photometry for **CT Car** means that the $(K, J-K)$ radius of 94.4 ± 2.8 unambiguously excludes any possibility that this star is anything but a classical Cepheid.

Phase coverage with good radial velocities is rather incomplete for **GY Sge**, and the phasing is more ambiguous than would be desirable. Nevertheless, the $(K, J-K)$ solution for the GY Sge phase interval for which RV data are available gives a radius of about 233 ± 12, a normal Type I value.

For **S Vul**, older data (heavily smoothed) have been used to patch the gap in the modern data, and phasing is unambiguous. The $(K, J-K)$ and $(K, V-K)$ radii are 271 and 272, respectively, with an uncertainty of about 14. S Vul is about the same radius as Type I Cepheids of similar period in the Magellanic Clouds.

3. Type X?

TX Del is a well known binary Cepheid with an orbit (Harris & Welch 1989) whose size seems to compel Type II status. I have used their pulsational radial velocity curve, phase shifted so that the surface brightness is normal for a Cepheid with the observed colour indices. The $(K, J-K)$ radius obtained is 47.6 ± 5.4, and the $(K, V-K)$ radius is considerably larger regardless of the phasing. Agreement between the $(K, J-K)$ and $(K, V-K)$ radii can only be obtained if the phasing is set so that the surface brightness coefficients are highly abnormal, and in that case the radius becomes about 75. This might be explained as the effect of a bright red companion, but the type of companion required would produce a J-K much redder for the observed B-V than is the case. TX Del is *normal* in the ratio of these two colours. Alternatively one might restrict the radius solution to the descending branch. This gives a $(K, V-K)$ radius of 45.6, about the same as for $(K, J-K)$ (which is not much affected by the restriction). TX Del appears to be far too large (and bright) to be a normal Type II Cepheid. A second difference between Type I and Type II Cepheids also highlights the oddity of TX Del. The amplitude in $J-K$ is always more than half the K amplitude for Type I, typically much less for Type II. TX Del is the only star yet tested which has a $J-K$ amplitude *larger* than its K amplitude.

TX Del almost seems to need a type of its own.

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