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R.T. Schilizzi, S. Vogel, F. Paresce and M. Elvis

Cool Giant Stars are Bigger at 712 nm than at 754 nm

A. Quirrenbach

University of California, San Diego, Center for Astrophysics and Space Sciences, Mail Code 0424, La Jolla, CA 92093-0424, USA

D. Mozurkewich and T. Armstrong

Naval Research Laboratory, Washington, DC, USA

D. Buscher

Cavendish Laboratory, University of Cambridge, Cambridge, UK

C. Hummel

US Naval Observatory, Washington, DC, USA

1. Observations and Data Reduction

We used the Mark III Optical Interferometer on Mt. Wilson in 1991 and 1992 to measure the diameters of 42 stars with 10 nm wide filters centered at 712 nm and at 754 nm. These filters probe the stellar atmosphere in a strong TiO band (712 nm) and in a "continuum" band relatively free of TiO absorption (754 nm). The data were taken on a North-South baseline that could be configured to lengths between 3.0 m and 31.5 m. Observations of the target stars were interleaved with frequent measurements of calibrator stars. The square of the calibrated visibility amplitude V^2 was determined as a function of baseline length, and a uniform disk model fitted to these data (for details see Mozurkewich et al. 1991). The average formal error of the diameter measurements – derived from the χ^2 of the model fits – is 2.5%. Data for a subset of 12 stars have already been published (Quirrenbach et al. 1993).

2. Results and Discussion

K stars, M0 stars, and carbon stars have identical diameters at 712 nm and at 754 nm. For stars with spectral types later than M0, the diameters are systematically larger at 712 nm than at 754 nm (see Figure 1). The diameter ratio increases with decreasing effective temperature (or increasing $R-I$ color index), and it is larger for luminosity class I than for luminosity class II and III stars. For C and S stars, which do not have TiO absorption bands, the diameter ratio is consistent with one, as expected.

The variation of the uniform disk diameter between 712 nm and 754 nm cannot be due to wavelength-dependent variations of the limb darkening, which is a much smaller effect. The observations can be qualitatively explained by the different TiO opacities in the two filters: the $\tau = 1$ surface occurs at a

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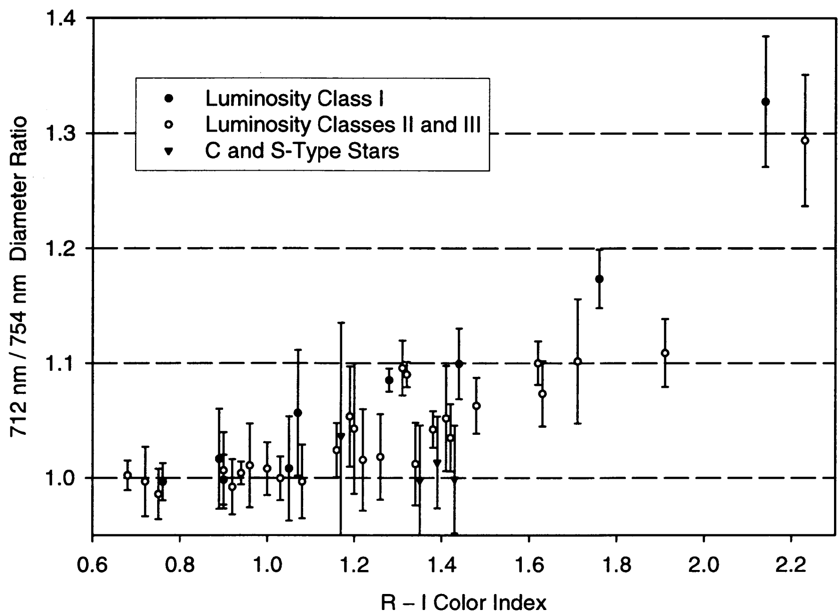
Figure 1. Ratio of stellar diameters at 712 nm and 754 nm, as a function of $R-I$ color index. Stars with $R-I \lesssim 1.2$ have identical diameters at the two wavelengths, at larger $R-I$ the diameter ratio increases. It is systematically larger for supergiants (luminosity class I) than for giants (luminosity classes II and III) with identical colors.



higher layer within the TiO bands than in the continuum. The atmosphere of cool giant stars is so distended that this effect leads to a measurable difference (up to ~ 30% for the coolest M supergiants) in the observed stellar diameter. However, the observed 712 nm / 754 nm diameter ratios are larger than predicted by standard model atmospheres. This indicates that the current models do not adequately describe the TiO opacity in the tenuous outer layers of the atmosphere or at the base of the wind. Our observations lend support to the idea of an extended "molecular sphere" around cool giant and supergiant stars (Tsuji 2000). Wavelength-dependent measurements of stellar diameters with the new generation of optical interferometers will provide a powerful new tool for the study of stellar atmospheres.

References

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