A Variation on the Baade-Wesselink Technique

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Consider a radially pulsating star. Expand the radius variation in a Fourier series:

\[ R = R_0 + \Delta r \cos(\omega t + \phi_1) \]

(summation convention). The velocity is

\[ v = -\omega A \sin(\omega t + \phi_1) \]

The ratio of the radii at two phases of the cycle may be written

\[ \left( \frac{R_1}{R_2} \right)^2 = \frac{L_1 T_2^4}{L_2 T_1^4} \equiv a. \]

Setting \( R = R_0 + \Delta r \) (\( \Delta r / R_0 \ll 1 \)), we obtain

\[ R_0 = 2\omega (\Delta r_2 - \Delta r_1) / (1-a). \]

The radial excursion \( \Delta r \) at any phase of the pulsation may be determined from a Fourier fit to the observed velocity curve. Assuming highly accurate velocity data (e.g. CORAVEL data), this can be done very precisely. If we choose phase 2 to be that for which \( \Delta r_2 = 0 \), we have

\[ a = \frac{2}{R_0} (\Delta r_1) + 1. \]

Obtaining energy scans at various values of \( \Delta r_1 \), we may use model atmospheres to determine the function \( a(\Delta r_1) \) from Eq. (1). Then, the slope yields \( R_0 \) via Eq. (2). Since the zero point is constrained \( a(0) = 1 \), we have a check on our determination of \( a \) from the energy scans. Another check comes from choosing \( \Delta r_2 \) in a different way - namely, to correspond to the maximum positive displacement. In that case, \( a \) must attain its minimum value at the minimum of \( \Delta r_1 \). We discuss the use of these variations to determine the radius \( R_0 \) and to test the application of model atmospheres to pulsating stars.