

An Expanded Bandpass List for Atmospheric Emission in Eclipsing Binary Models

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Abstract. Programs for modeling binary star observables compute emergent intensity for given composition as it varies with local effective temperature, local gravity, and direction. With arrival of huge data sets from Gaia and other surveys, the benefits of fast, compact, and accurate computation of atmospheric radiation is likely to remain critical for the foreseeable future. Experience has shown that accurate radiative modeling is important for good parameter estimation. Here we augment the radiative treatment by Van Hamme & Wilson (2003) with a procedure by which individuals can generate the needed Legendre coefficients for arbitrary photometric bands. Resulting files can be inserted directly into the Wilson-Devinney (W-D) program without sacrificing portability or program unity, and should easily be adaptable to other binary star programs. We expect the new bandpass options to become part of the public W-D program. Limb-darkening tables will be placed at <http://www.fiu.edu/~vanhamme/limdark.htm>.

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1. Introduction

A compact, fast and portable program to obtain emergent intensities in the observer's direction at an arbitrary surface point of a binary star is described in Van Hamme & Wilson (2003). The method is based on Kurucz stellar atmosphere grids (Kurucz 1993; <http://kurucz.harvard.edu>). Kurucz provides intensities at 1221 wavelengths from 9 to 160 μm , and for 11 $\log g$'s from 0.0 to 5.0 (cgs). Temperature ranges depend on $\log g$ and abundance $[M/H]$, with the largest range for any $\log g$ being from 3500 K to 50000 K (specific temperature limits and abundances can be found in Kurucz 1993). Intensities are integrated over bands and weighted by band response functions. References for current bands are in Wilson & Van Hamme (2003). Irrespective of abundance or surface gravity, Legendre polynomials represent intensities very well as functions of T_{eff} in 4 subintervals, with beginning and end points dependent on bandpass and model. Coefficients of Least Squares fitted Legendre polynomials are stored in a data file and can be provided to a suitably designed eclipsing binary (EB) program, such as that of Wilson & Devinney (W-D, Wilson & Devinney 1971; Wilson 1979, 1990). Mean deviations between actual and approximated intensities rarely exceed a few percent, with typical deviations of the order 0.001 in \log_{10} of intensity. Figure 1 shows model intensities and Legendre fits for the Gaia G band. Beyond available T_{eff} and $\log g$ ranges, W-D makes smooth transitions to blackbody intensities in intervals set by the user.

2. Problem

Many more standard photometric systems exist than the 25 currently in W-D. Space-based surveys (existing and planned) use very specific and custom designed bands. The

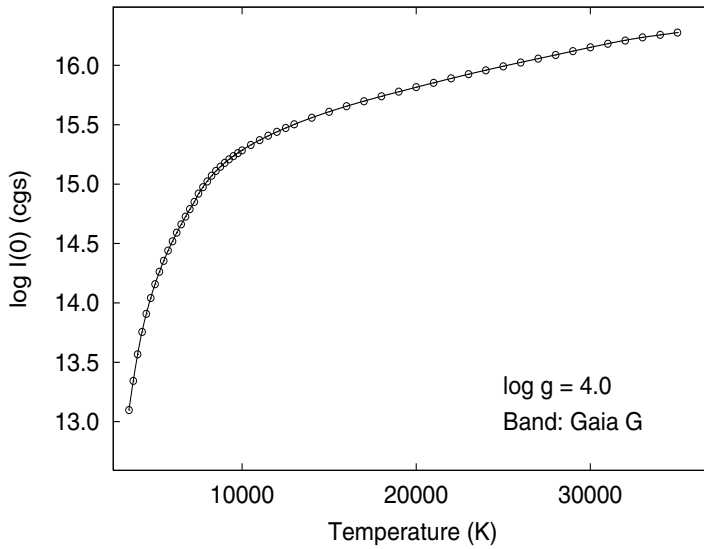


Figure 1. Normal emergent intensity in $\text{erg s}^{-1} \text{cm}^{-3} \text{sr}^{-1}$ of a solar composition atmosphere for the band and $\log g$ indicated. Circles are stellar atmosphere intensities and lines represent the Legendre fits in separate intervals 3500 K – 4250 K, 4250 K – 7500 K, 7500 K – 7750 K and 7750 K – 35000 K.

Table 1. Sample alternative W-D Bandpass List

Band	Reference
Geneva <i>U, B, B1, B2, V, V1, G</i>	Rufener & Nicolet (1988)
Vilnius <i>U, P, X, Y, Z, V, S</i>	Straizys & Zdanavičius (1965)
Young & Milone <i>iz, iJ, iK, iK, iL, iL', iM, in, iN</i>	Young, Milone & Stagg (1994)
Gaia <i>G</i>	Jordi <i>et al.</i> (2006)

temperature range of the Kurucz atmosphere grid prevents treatment of very cool [dwarfs, brown dwarfs (for example, see Stassun *et al.* 2006), giants] or hot stars.

3. Solution

New bands with corresponding data files of Legendre coefficients, such as those of Table 1, will be inserted in the W-D program in the reasonably near future. We need a flexible program that generates the required atmosphere data file for user-specified bands and allows seamless integration into W-D or another EB program. FORTRAN programs that execute tasks outlined in the flow chart below have been written and are in the final testing stages. They will be available for distribution from the WWW site <http://www.fiu.edu/~vanhamme>.

References

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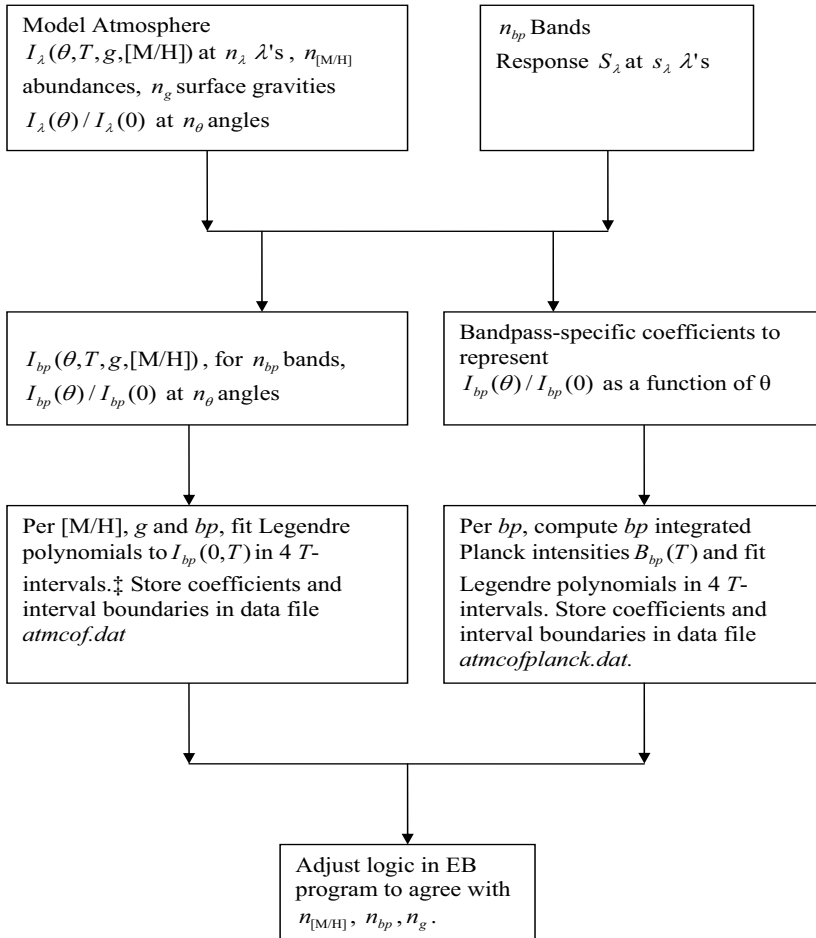


Figure 2. Flow chart indicating tasks for generating EB stellar atmosphere data. The step indicated by the ‡ sign is the most labor intensive. For each band and log g , optimal T -interval boundaries have to be determined by visually inspecting fitted curves graphed on top of model intensities and by tracking the actual residuals between fitted and model intensities.

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