

The “Including All the Lines” Project

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Abstract. I present a progress report on including all the lines in the line lists, including all the lines in the opacities, and including all the lines in the model atmosphere and spectrum synthesis calculations. The increased opacity will improve stellar atmosphere, pulsation, stellar interior, asteroseismology, nova, supernova, and other radiation-hydrodynamics calculations. I also report on producing high-resolution, high-signal-to-noise atlases for use in verifying the line data and spectrum calculations, and as tools for extending laboratory spectrum analyses to higher energy levels. All the data are available on my website kurucz.harvard.edu.

In updating previous calculations I generally compute three times as many levels, including all the most recent laboratory data, and produce ten times as many lines. With the addition of heavier elements that were not previously computed I expect to have more than one billion atomic lines. At this writing I have completed 62 ions, mostly iron group, that produced 260 million lines. I am also revising and adding to my diatomic molecular data. Large scale results will take one or two more years. I will produce a wavelength-sorted line list with all the lines for opacities and a second list with all the lines with accurate wavelengths for computing detailed spectra.

For each ion I save the least squares fits; energy level tables with E, J, identification, strongest eigenvector components, lifetime, A sum, C_4 , C_6 , and Landé g; electric dipole, magnetic dipole, and electric quadrupole line lists. Eigenvalues are replaced by measured energies when data exist. Lines connecting measured levels have correct wavelengths, but most of the lines have predicted, uncertain wavelengths. Lines have radiative, Stark, and van der Waals damping constants, Landé g, and branching fractions. Hyperfine and isotopic splitting are included when laboratory data exist. Laboratory measurements of gf values and lifetimes are included. I have started to include measured or estimated widths of autoionizing levels and measured or estimated Shore parameters for Fano profile lines.

I already have production programs that can treat billions of lines. My program DFSYNTH can tabulate opacity spectra and opacity distribution functions (ODFs). Model atmosphere program ATLAS9 uses ODFs for opacity while ATLAS12 uses opacity sampling.