Fast Spectral Synthesis for a New Generation of Solar and Stellar Brightness Variability Models

Miha Černetič *[1,2] [miha@filetki.si], A. I. Shapiro [2], N. A. Krivova [2], S. K. Solanki [2,3], V. Witzke [2], and R. V. Tagirov [4]*

[1] *Dept. of Physics, University of Ljubljana, Ljubljana, Slovania*
[2] *Max-Planck-Institut für Sonnensystemforschung, Göttingen, Germany*
[3] *School of Space Research, Kyung Hee University, Gyeonggi, Republic of Korea*
[4] *Physics Dept., Imperial College London, South Kensington Campus, London, United Kingdom*

Currently a new generation of models of solar and stellar brightness variability based on the realistic three-dimensional magnetohydrodynamic simulations of atmospheres is being developed, in particular when applied to the many pixels in a 3D MHD simulation. The standard procedure used for the radiative transfer is computationally very expensive. This is due to the treatment of the spectral lines: The spectra of the Sun and Sun-like stars contain several millions of molecular and atomic lines that play an important role in the irradiance variability in the UV and visible spectral domains. Therefore, an optimization of the spectral line calculations is urgently required. One possible approach is the employment of the opacity distribution functions (ODFs). They allow taking into account the effect of spectral lines by approximating their complex structure in opacity. We investigate the procedure used for ODF computations and develop a novel approach for fast calculations of a) integrated flux and its variability in passbands of interest, e.g. in Strömgren-, Kepler-, and Plato- filters; b) the total solar irradiance (TSI) and its variability. In particular, we show that it is sufficient to calculate the radiative transfer of just about a hundred frequency points to accurately reproduce the TSI and its variability. Our method and the related speed-up in radiative transfer calculations allows the current models to be taken to a new level, making it potentially possible to investigate a whole range of new phenomena.