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Time-dependent radiative transfer with PHOENIX (Corrigendum)

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4. Time-dependent radiative transfer

The equation of radiative transfer is given by:

$$\frac{\lambda}{\lambda_\infty}\frac{1}{c}\frac{\partial I_\lambda}{\partial t}\bigg|_\lambda + \frac{\partial I_\lambda}{\partial s}\bigg|_\lambda + \frac{\mathrm{d}\lambda}{\mathrm{d}s}\frac{\partial I_\lambda}{\partial \lambda} = -\left(\chi_\lambda + \frac{5}{\lambda}\frac{\mathrm{d}\lambda}{\mathrm{d}s}\right)I_\lambda + \eta_\lambda,$$

where $\lambda_\infty/\lambda = \gamma(1+\beta\mu)$ is the Doppler factor (Baron et al. 2012). In the original work the transformation of the time-dependent term from frequency space to wavelength space was neglected. Thus, our discussion of Eqs. (24)–(27) should read:

For an implementation of the time dependence in the radiative transfer itself, the spherical symmetric special relativistic radiative transfer equation (SSRTE) for expanding atmospheres (Hauschildt & Baron 1999) is extended so that the additional time-dependent term is given by

$$[\gamma(1+\beta\mu)]^{-1}\frac{1}{c}\frac{\partial I}{\partial t} \tag{24}$$

where $\beta = \frac{v}{c}$ is the velocity in units of the speed of light c and $\gamma = (1-\beta^2)^{-1/2}$ is the usual Lorentz factor. Here, I is the intensity, μ the cosine of the angle between the radial direction and the propagation vector of the light. Using the notation of Hauschildt & Baron (2004), the comoving frame SSRTE with the additional time-dependent term is given by

$$a_t\frac{\partial I}{\partial t} + a_r\frac{\partial I}{\partial r} + a_\mu\frac{\partial I}{\partial \mu} + a_\lambda\frac{\partial \lambda I}{\partial \lambda} + 4a_\lambda I = \eta - \chi I \tag{25}$$

where η is the emissivity and χ the extinction coefficient. The wavelength is represented by λ. The additional time-dependent coefficient is given by

$$a_t = [\gamma(1+\beta\mu)]^{-1}\frac{1}{c}\cdot \tag{26}$$

Along the characteristics the equation has the form

$$\frac{\mathrm{d}I_l}{\mathrm{d}s} + a_t\frac{\partial I}{\partial t} + a_l\frac{\partial \lambda I}{\partial \lambda} = \eta_l - (\chi_l + 4a_l)I_l \tag{27}$$

where ds is a line element along a (curved) characteristic and $I_l()$ is the specific intensity along the characteristic at point $s \geq 0$ ($s = 0$ denotes the beginning of the characteristic). For a definition of the other coefficients see Hauschildt & Baron (2004).

For the tests presented in this paper, the error is small, since the velocities considered were less than 10% of the speed of light, but it will affect the results at the 10% level. We have tested that the correction does not materially alter our conclusions.

References

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