Geophysical Research Abstracts
Vol. 14, EGU2012-8343, 2012
EGU General Assembly 2012

Polarized radiative transfer equation in several astrophysically interesting coordinate systems

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While modeling multiple light scattering in astrophysical objects generally it is necessary to make numerical 3D radiative transfer calculations in objects of irregular morphology. But often their shape can be approximated by some regular geometry, e.g. plane-parallel, spherical, cylindrical, conical, spheroidal or toroidal.

There are few theoretical results concerning radiative transfer in nonplanar geometries, namely, only for spherical and cylindrical coordinate systems. But the numerical solution of any equation generally performs best if the numerical method accounts for the analytical properties of the solution, first of all – its singularities and asymptotics. This justifies further theoretical research of radiative transfer in different coordinate systems, and first of all, the transfer equation itself in different coordinate systems must be written down.

General method allowing to obtain clear expression for the differential operator of polarized radiative transfer equation (PRTE) in arbitrary curvilinear spatial coordinate system was recently described [1]. Here it is applied to several orthogonal coordinate systems essential for astrophysical applications.

PRTE in circular conical coordinate system is treated as a particular look upon PRTE in spherical coordinate system. Previously obtained expressions for PRTE in elliptic conical coordinate system [2] are simplified using Lukáčs [3] trigonometric parameterization of the coordinates. PRTE in triaxial ellipsoidal system is obtained by merger of parameterization of angular coordinates described in [3] with my own ideas; PRTE in oblate spheroidal and prolate spheroidal system appear as particular cases of it in two types of the ellipsoidal system. PRTE in two different kinds of toroidal coordinate system (classical and simple) is derived as well.

References

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