GYROSYNCHROTRON RADIATION CODE:

EQUATION OF RADIATIVE TRANSFER

INTEGRATOR

DOCUMENTATION

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Description

This program, GYRORT, computes gyrosynchrotron radio spectra by integrating the equation of radiative transfer along the line of sight through an inhomogeneous source region. It accounts for the index of refraction of the emitting plasma, but does not compute ray paths. The ray path is assumed to be a straight line. Program GYRORT drives Subroutine GETGSE and its subprograms, replacing Program GYROSPEC.

The file gyrort.for replaces the file gyrospectrum.for in Gyrospec. To run the program, the following files must be compiled and linked:

gyrort.for
getgse.for
dcadre.for
dmlin.for
mmbsjn.for
odeint.for
fdblpl.for
getgse.inc

Subroutine GETGSE and its subprograms are described in the documentation for Gyrospec, gyrodoc.pdf.

The IDL routine GYRORTPLOT.PRO reads and plots the output from GYRORT as a function of radio frequency. Plots of radio flux, brightness temperature, fractional polarization, and total optical depth as a function of radio frequency are displayed in four separate windows.

The equation of radiative transfer is integrated as a pair of coupled equations for the optical depth, τ, and the radiation intensity divided by the index of refraction squared, I/n^2:

$$\frac{d\tau}{dx} = K$$

$$\frac{d}{dx}\left(\frac{I}{n^2}\right) = \frac{j}{n^2}e^{-\tau}$$

Here j is the gyrosynchrotron emissivity and K is the absorption coefficient. The equations are integrated along the line of sight from the edge of the source closest to the observer (x = 0) to the distant edge of the source (x = DEPTH).

The equation of radiative transfer is integrated in Subroutine ODEINT using fifth-order Runge-Kutta steps with adaptive stepsize control. This subroutine and the Runge-Kutta subroutines in the file odeint.for are adapted from Press et al., Numerical Recipes in Fortran 77, Second Edition (Cambridge University Press, 1992).

The fractional error in the integration steps, as for the integration routines for the gyrosynchrotron emission and absorption coefficients (see gyrodoc.pdf), is controlled by the variable RERR. The stepsize is rescaled until the result for both equations is within the specified fractional error.

The equations for the optical depth and radiation intensity are provided in Subroutine DERIVS. Subroutine GETGSE is called from DERIVS. A double-power-law electron distribution function is provided by Subroutine DISTRN in the file fdblpl.for. As in Program GYROSPEC, to facilitate the numerical integration DERIVS integrates the electron distribution function in two parts, above and below the double-power-law break energy, GAMBRK, and sums the parts.

The sample computation provided with the program is for a simple linear increase in magnetic field strength from 400 to 600 Gauss along the line of sight. This is specified in Subroutine BGAUSS. The resulting radio spectra can be compared with those computed for a constant field strength of 500 Gauss by Program GYROSPEC. The variation of other physical parameters within the radio source can be specified by modifying Program GYRORT to call additional subroutines similar to BGAUSS.

Contact

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