ROCOTLIB

A Coordinate Transformation Library for Solar-Terrestrial studies

The ROCOTLIB library (RObert's COordinate Transformation LIBrary) is a set of software modules to perform transformations between the various coordinate systems used in geophysical and magnetospheric studies. Most of the frames of reference are geocentric, and are thus independent of the position of the point of observation ; nevertheless, some local frames are also considered.

In addition to coordinate transformations, the library also provides a set of modules to perform format conversion and other operations associated with epoch, date and time.

This library was originally developed in 1992 by P. Robert of CNRS/CRPE, with support from ESA within the framework of preparation of the CLUSTER mission; since then it has been regularly updated by the author. The CDPP documentation and software are mutually compatible ; occasionally more recent version (V1.8) may be found on the CETP server.

ROCOTLIB exists in both FORTRAN 77 and in FORTRAN 90, and of course can be run on any computer where these compilers are available. It will soon be available in the IDL and PV-Wave programming languages. Each transformation or module corresponds to a subroutine in FORTRAN, and to a procedure in IDL or PV-Wave. The package delivered to the user includes sources and makefiles of the library, examples of its use, a test program and the corresponding test output file to check the validity of the installation on the user's machine. The test programme has been developed and tested using the following FORTRAN compilers :

- SunOS 5.8 and SunOS 5, Sun WorkShop Compiler FORTRAN 77 V 5.0
- The same systems, with FORTRAN 90 V2.0
- LINUX /Intel i686 , g77 - GNU project FORTRAN Compiler (v0.5.24)
- DEC OSF/1, Digital FORTRAN 90 for Digital UNIX Alpha Systems V4.0

The installation on any system with a FORTRAN compiler is very easy ; it entails only recovery of the installation package, and then execution of the makefiles. This creates the library object *rocotlib.o*, plus the executable files *rocotexp.exe* and *rocotche.exe* of the example and the test programs.

The *rocotexp.f* sample source program is shown below, illustrating its simplicity of use. It can be modified by the user according to his needs. After modification of the source file, a single command such as *f77 rocotexp.f rocotlib.o -o rocotexp.exe* produce the executable file *rocotexp.exe* which is ready to run.

```
      program rocotexp

c     ------------------------------------------------------
c *   Rocot_Example of using Rocotlib
c     ------------------------------------------------------

      print*
      print*, 'ROCOTEXP:'
      print*

      call redate(iyear,imonth,iday)
      call retime(ih,im,is)

      call ctimpar(iyear,imonth,iday,ih,im,is)
      call gsundir(sxgei,sygei,szgei,sxgeo,sygeo,szgeo)
      call tgeigsm(sxgei,sygei,szgei,sxgsm,sygsm,szgsm)

      print*
      print*, 'date: MM/JJ/YY=', imonth,iday,iyear
      print*, 'time: HH/MM/SS=', ih,im,is
      print*
      print*, 'Sun in GEI:',sxgei,sygei,szgei
      print*, 'Sun in GEO:',sxgeo,sygeo,szgeo
      print*, 'Sun in GSM:',sxgsm,sygsm,szgsm
      print*

      stop 'rocotexp: normal termination'
      end
```

Example of use of rocotexp.f

This example show the four families of subroutines :

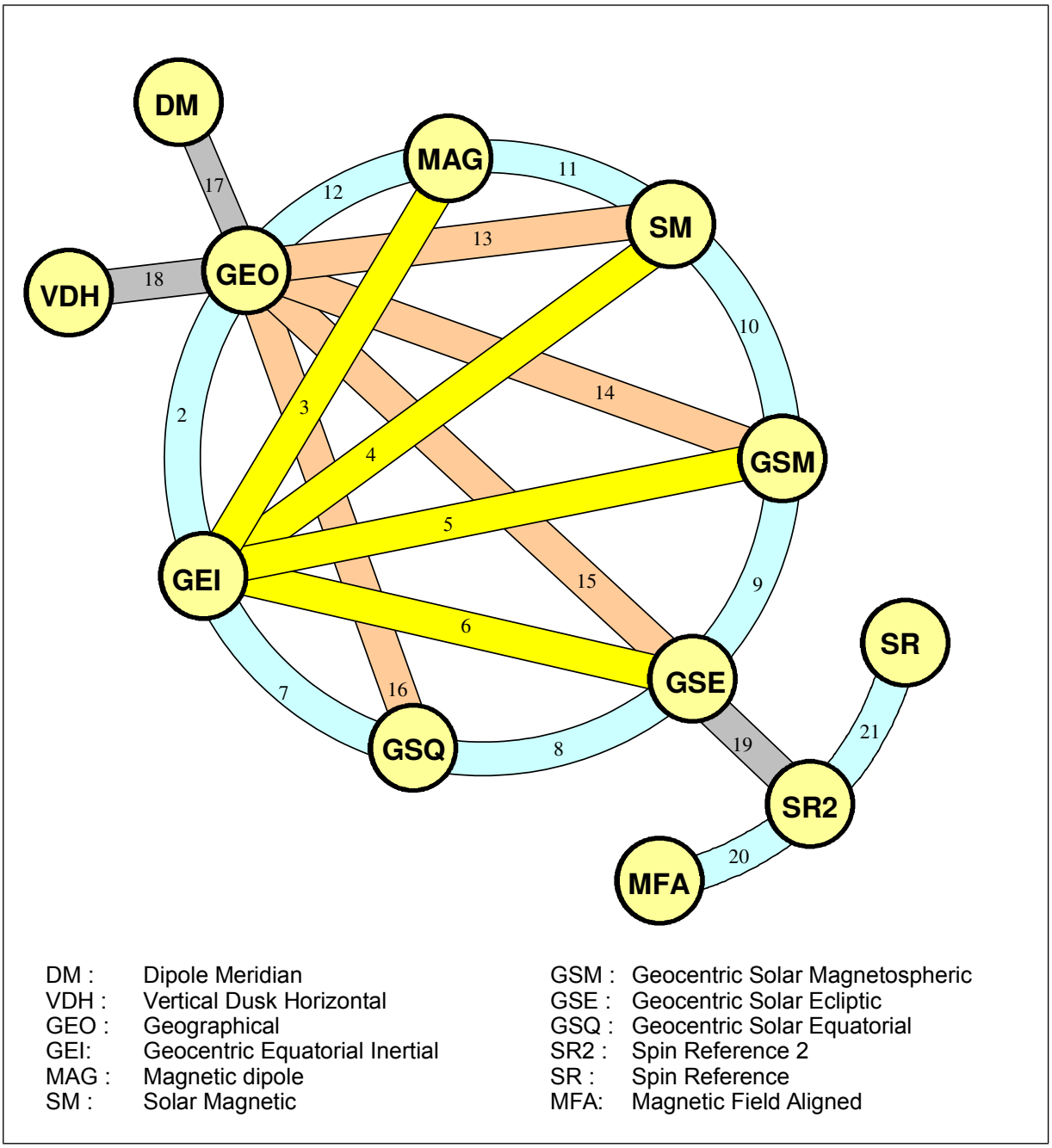
- The *redate* and *retime* subroutines, meaning "*read_date*" and "*read_time*", read a given date and time from the standard input.
- The *ctimpar* subroutine, meaning "*compute_time_parameter*", computes and stores in memory all the parameters and time dependent matrices, allowing further coordinate transformations. This routine must be called whenever the time is changed.
- The *gsundir* subroutine, meaning "*give_sun_direction*", gives the direction of the Sun in the GEI and GEO system at the considered time.
- The *tgeigsm*, meaning "*transform_gei_to_gsm*", transform a Cartesian vector given in the GEI system to the GSM system.

Many coordinate systems and transformations are available, as shown in the schematic diagram. The coordinate systems lying on the large blue ring are geocentric, SR, SR2 and MFA are spacecraft centred, while VDH and DM are local terrestrial systems. The numbers refer to the transformation modules. For two frequently used systems, the GEOgraphic (GEO) and the Geocentric Equatorial Inertial (GEI) systems, there are modules to transform directly to any other geocentric system. Coordinate transformations with no direct link have no corresponding software module ; for example, to pass from GSE to SM coordinates requires at least two modules, passing via one of three intermediate systems, GEI, GEO, or GSM ; whatever the route, the overall result is the same. Some transformations involve a change of origin ; they pass via either the GEO or GSE systems, along the grey lines, and they require knowledge of either the origin of the new coordinates expressed in GEO coordinates (modules 17 and 18), or the direction of the spacecraft spin axis in GSE coordinates (module 19).

The recovered software package is accompanied by a PDF file which contains the complete documentation, in two parts :

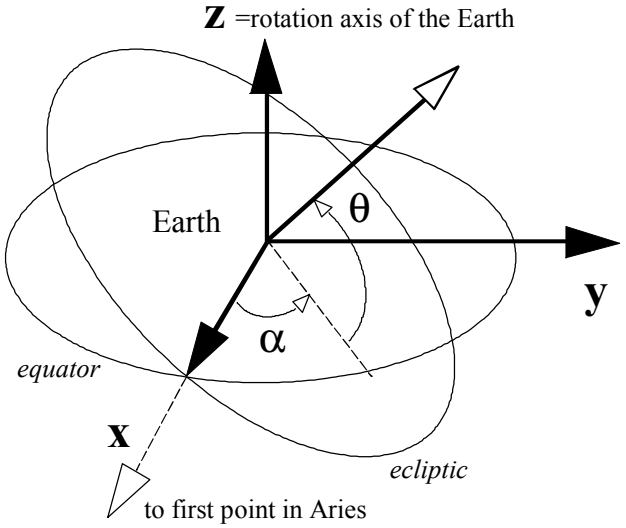
- The first defines the various coordinate systems considered, and gives the mathematical formulas and matrices to pass from one system to another. As example, the definition of the GEI system is shown below.
- The second part is the user's manual for the FORTRAN library. It give the complete list of available modules, the role for each one, and a description of the input and output variables. The example programs and the test program are also commented.

This library is an evolving product which may eventually be enriched by additional transformations or applications. Any comments are welcome.



Schematic diagram of transformations

Geocentric Equatorial Inertial system (GEI)



The Z-axis is parallel to the Earth's rotation axis.
The X-axis is defined by the intersection of the geographic equatorial plane and the ecliptic plane, and is pointing towards the first point of Aries (the position of the Sun at the vernal equinox).

The *right ascension* α and the *declination* θ are defined by :

right ascension $\alpha = \tan^{-1}(V_y/V_x)$ with $0° \le \alpha < 180°$ for $V_y \ge 0$
$180° \le \alpha < 360°$ otherwise

declination $\theta = \sin^{-1}(V_z/V)$ with $-90° \le \theta \le +90°$

Example of definition of GEI system