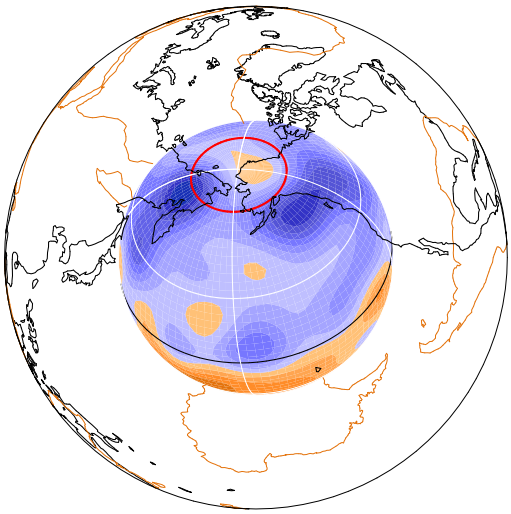
LEOPACK



mfcanal1

Magnetic **F**ield **C**omponent **ANAL**ysis

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1 mfcanal1

Magnetic **F**ield **C**omponent **ANAL**ysis

This program calculates the function

$$F(B_r, B_\phi) = \frac{\int_V B_r B_\phi dV}{\int_V |B_r| dV \int_V |B_\phi| dV} \tag{1}$$

for a solution vector in standard form (i.e. `.ints`, `.vecs` and `.xarr` format), where $\int_V$ denotes an integral over the full volume of the sphere or spherical shell.

The stand-alone source code version of the program is compiled by typing

```
make samfcanal1
```

within this directory. Once the executable is created, begin execution by typing

```
mfcanal1 < inputfile
```

Each of the integrands is evaluated in real space; the fundamental field components are evaluated on this grid using the subroutine `SV2XSA`, and the subroutine `XSFANAL1` - which is simply an integral part of the `mfcanal1.f` source code file. It is basically up to the user to modify this source code as necessary to obtain the integral function required; the best way is simply to look at the code and adapt.

A little "check" on the validity of the integral is provided by a calculation of the integral of the magnetic energy term

$$ME = \frac{1}{2} \int_V \boldsymbol{B}.\boldsymbol{B} dV. \tag{2}$$

This can also be calculated using the subroutine **SHKEER** - which is indeed how it is done in most of the time-stepping codes.

In the subroutine `XSFANAL1`, we calculate B_r, B_θ and B_ϕ from the individual components (see the subroutine `SV2XSA`) and then calculate the magnetic energy integrand using

```
TOTME  = BRAD*BRAD + BTHE*BTHE + BPHI*BPHI
```

and then

```
XSF( 20, IPHP, ITHP, IR ) = TOTME*0.5d0.
```

These array elements then hold the $\boldsymbol{B}.\boldsymbol{B}/2$ integrand over the grid of r, θ and ϕ points.

The integral is then simply calculated by the code segment

```
      ICM = 20
      CALL XSVSCI( NCMX, NPHP, NTHP, NR, ICM, XARR, GAUW,
     1             XSF, DINT )
```

where `DINT` contains the integral.

If this integral agrees with that calculated by **SHKEER** - which calculates magnetic energies using the poloidal and toroidal spherical harmonic radial functions rather than single components in real space - then this is a good indicator that our integration process is good and the correct result merely requires the correct calculation of the integrand in `XSFANAL1`.

The inputs file must have the following format.

```
* input file for mfcanal1
root.ints                    : Harmonics File
root.vecs                    : Vector File
root.xarr                    : Radial Spacings
example_aOUTPUT.mfca         : Output file name
```

Any line in the input file beginning with an asterisk, `*`, is ignored by the program and can thus be used to enter comments and notes.

The arguments are as follows

- `Output file name`: obvious
- `Harmonics File`: Name of `.ints` file
- `Vector File`: Name of `.vecs` file
- `Radial Spacings`: Name of `.xarr` file

1.1 Subprograms required for mfcanal1

SUBS subroutines

```
hmfrd.f svfrd.f xarrrd.f fopen.f svfdcf.f ontppf.f
gauwts.f schnla.f casvd2.f shkeer.f sv2xsa.f xsvsci.f
fclose.f fnamer.f ldgnmf.f gfdcfd.f asvdr.f vecop.f
fftrlv.f matop.f powtwo.f
```

SUBS double precision function

```
emmult.f pmm.f   pmm1.f  plm.f   dpmm.f  dpmm1.f
dplm.f  sqrll1.f
```

SUBS integer function

`indfun.f`

BLAS integer function

`idamax.f`

BLAS subroutines

```
dgemm.f dtrsm.f dgemv.f dswap.f dger.f  dscal.f
dtrmm.f dtrmv.f
```

LAPACK subroutines

```
dgetrf.f dgetri.f dgetf2.f dlaswp.f xerbla.f
dtrtri.f dtrti2.f
```

LAPACK integer function

`ilaenv.f`

LAPACK logical function

`lsame.f`

1.2 Run-time limitations

Several parameters are set at the outset which limit the physical size of the problem.

```
 INTEGER NHMAX, LHMAX, NDCS, NRMAX, ISVMAX, NBN, NCFM,
1        NDRVM, NPHMAX, NTHMAX, NPMAX, NCMX
 PARAMETER ( NHMAX = 1700, LHMAX = 50, NDCS = LHMAX + 2,
1            NRMAX = 100, ISVMAX = NHMAX*NRMAX, NBN = 3,
2            NCFM  = 2*NBN + 1, NDRVM = 1, NCMX = 27,
3            NTHMAX = 64, NPHMAX = 128 )
 PARAMETER ( NPMAX = (LHMAX+1)*(LHMAX+2)/2 )
```

If the values are insufficient, then change them and recompile. (Note that `NDRVM` is not size dependent and should not be changed.)

- `NHMAX` is the maximum number of spherical harmonic radial functions allowed.
- `LHMAX` is the highest permitted spherical harmonic degree, l.
- `NRMAX` is the maximum permitted number of radial grid nodes.

- `NBN` is the number of bounding nodes on either side of the finite difference stencil. `NBN = 3` is recommended value, but it is harmless to increase it in this program.
- `NCMX` is the maximum number of scalar functions stored in the `XSV` array. This depends entirely on what the user wishes to convert the program for.
- `NTHMAX` is the maximum permitted number of grid nodes in θ for Gaussian quadrature in the spherical transforms.
- `NPHMAX` is the maximum permitted number of grid nodes in ϕ for the Fast Fourier Transforms.

1.3 Outputs from MFCANAL1

A single file with filename specified in the input file. It is up to the user who modifies the program to decide what it should read, but the current output is of the form

```
 LH     =  12
 NTHP   =  21
 NPHP   =  32
 Old calculation: ...
 Using SHKEER, the volume int. of magnetic
 energy is     9.5001835640225D-02
  --------------------------
 Using SV2XSA and XSVSCI,
 the volume int. of magnetic
 energy is     9.5001835640207D-02
  --------------------------
 integral of ( |B_rad| ) =     2.5127063596977D-02
 integral of ( |B_phi| ) =    0.65665416664763
 integral of ( B_rad*B_phi ) =    -3.6396294392870D-03
 Correlation of ( B_rad*B_phi ) =   -0.22058639638749
```

Firstly, we have checked upon the magnetic energy integral and then at the bottom return the function $F(B_r, B_\phi)$.

1.4 Sample runs of mfcanal1

The directory

`$LEOPACK_DIR/SAMPLERUNS/MFCANAL1`

contains example input files and model output. The input file `example_a.input` points to the output from a test case for krssgeps The output file, `example_aOUTPUT.mfca` is displayed above.

References