

makeSampleCMB

July 9, 2017

```
In [101]: import numpy as np
import healpy as hp
from astropy.io import fits
```

Set the Nside and related parameters

```
In [ ]: Nside = 1024
Npix = 12*Nside**2
```

Set the sample size by setting a 'sample Nside' and related parameters

```
In [102]: sNside = 256
sNpix = 12*sNside**2
```

Take the simple random sample (spix) from the collection of HEALPix pixels (pix)

```
In [ ]: pix = np.arange(1,12*Nside*Nside)
spix = np.random.choice(pix,12*sNside*sNside)
```

Connect to file and look at the header units

```
In [103]: filename = "../../../CMB_map_smica1024.fits"
data, header = fits.getdata(filename, header=True)
hdulist = fits.open(filename)
hdulist.info()
```

Filename: ../../../CMB_map_smica1024.fits

No.	Name	Ver	Type	Cards	Dimensions	Format
0	PRIMARY	1	PrimaryHDU	16	()	
1	COMP-MAP	1	BinTableHDU	61	12582912R x 5C	[E, E, E, B, B]
2	BEAMTF	1	BinTableHDU	45	4001R x 2C	[E, E]

Show full header before we modify NSIDE, NAXIS2, LASTPIX, RESOLN, and TTYPE4

```
In [104]: print("Before modifications:")
print()
print("Extension 0:")
print(repr(fits.getheader(filename, 0)))
print()
print("Extension 1:")
print(repr(fits.getheader(filename, 1)))
```

Before modifications:

Extension 0:

```
SIMPLE = T / Written by IDL: Fri Jul 17 14:54:31 2015
BITPIX = 8 / Number of bits per data pixel
NAXIS = 0 / Number of data axes
EXTEND = T / FITS data may contain extensions
DATE = '2015-07-17' / Creation UTC (CCCC-MM-DD) date of FITS header
COMMENT FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT and Astrophysics', volume 376, page 359; bibcode 2001A&A...376..359H
NUMEXT = 2 / Number of extensions
FILENAME= 'COM_CMB_IQU-smica_1024_R2.02_full.fits' / FITS filename
COMMENT
COMMENT -----
COMMENT CMB products from smica component separation method
COMMENT -----
COMMENT For further details see Planck Explanatory Supplement at:
COMMENT http://wiki.cosmos.esa.int/planckpla2015
COMMENT -----
```

Extension 1:

```
XTENSION= 'BINTABLE' /Written by IDL: Fri Jul 17 14:54:32 2015
BITPIX = 8 /
NAXIS = 2 /Binary table
NAXIS1 = 14 /Number of bytes per row
NAXIS2 = 12582912 /Number of rows
PCOUNT = 0 /Random parameter count
GCOUNT = 1 /Group count
TFIELDS = 5 /Number of columns
COMMENT
COMMENT *** End of mandatory fields ***
COMMENT
EXTVER = 1 /Extension version
DATE = '2015-07-17' /Creation date
COMMENT
COMMENT *** Column names ***
COMMENT
TTYPE1 = 'I_STOKES' /
TTYPE2 = 'Q_STOKES' /
TTYPE3 = 'U_STOKES' /
TTYPE4 = 'TMASK ' /
TTYPE5 = 'PMASK ' /
COMMENT
COMMENT *** Column formats ***
COMMENT
TFORM1 = 'E ' /
TFORM2 = 'E ' /
TFORM3 = 'E ' /
```

```

TFORM4 = 'B      ' /
TFORM5 = 'B      ' /
COMMENT
COMMENT *** Column units ***
COMMENT
TUNIT1 = 'K_CMB  ' / map units
TUNIT2 = 'K_CMB  ' / map units
TUNIT3 = 'K_CMB  ' / map units
TUNIT4 = '      ' / no units
TUNIT5 = '      ' / no units
COMMENT
COMMENT *** Planck params ***
COMMENT
EXTNAME = 'COMP-MAP' / Extension name
AST-COMP= 'CMB      ' / Component
RESOLN  =           10 / arcmin
PIXTYPE = 'HEALPIX ' /
POLCCONV= 'COSMO    ' / Polarization convention
COORDSYS= 'GALACTIC' / Coordinate system
ORDERING= 'NESTED   ' / Healpix ordering
NSIDE   =           1024 / Healpix Nside
FIRSTPIX=           0 /
LASTPIX =          12582911 /
FILENAME= 'COM_CMB_IQU-smica_1024_R2.02_full.fits' / FITS filename
BAD_DATA=          -1.63750E+30 / HEALPIX bad pixel value
METHOD  = 'smica    ' / Separation method
PROCVER = 'DX11     ' / Product version
COMMENT
COMMENT -----
COMMENT CMB products from smica, coverage full
COMMENT -----
COMMENT For further details see Planck Explanatory Supplement at:
COMMENT http://wiki.cosmos.esa.int/planckpla2015
COMMENT -----

```

0.0.1 The remainder of this notebook is incomplete and somewhat flawed

The idea was that we could create a smaller FITS file with a simple random sample of the original $N_{\text{side}} = 1024$ FITS file, then we could include it as sample data in the R package. Unfortunately the of HEALPix pixel indices is lost when we write the new file below. Hence we need to figure out how to insert a new column in the sample data frame containing the HEALPix indices of the sample, perhaps replacing PMASK or TMASK. This column could then be accessed by a slightly altered version of readFITScmb in R, designed to optionally take an array of pixel indices instead of the Nside parameter (which it currently takes).

Notice that spix contains the sample pixel indices, it is just a matter of writing it in place of PMASK or TMASK then changing the relevant header info. For example, here are the first 10 sample pixel indices:

```
In [107]: spix[:10]
```

```
Out[107]: array([ 8224723,  6155352, 12161074,  8611508,  6506440,   326030,
                  4636818,  6706995, 10273064, 11812486])
```

Write the new file with Nside = 256 random sample size, and then alter the header

```
In [108]: newfilename = 'CMB_testmap_1024_256sample.fits'
fits.writeto(newfilename, data[spix], header, overwrite=True)
fits.setval(newfilename, 'NSIDE', value=str(sNside), ext=1)
fits.setval(newfilename, 'NAXIS2', value=12*sNside*sNside, ext=1)
fits.setval(newfilename, 'LASTPIX', value=12*sNside*sNside-1, ext=1)
fits.setval(newfilename, 'RESOLN', value='NA', ext=1)
```

Look at header info after modifications

```
In [39]: print("After modifications:")
print()
print("Extension 0:")
print(repr(fits.getheader(newfilename, 0)))
print()
print("Extension 1:")
print(repr(fits.getheader(newfilename, 1)))
```

After modifications:

Extension 0:

SIMPLE	=	T / conforms to FITS standard
BITPIX	=	8 / array data type
NAXIS	=	0 / number of array dimensions
EXTEND	=	T

Extension 1:

XTENSION=	'BINTABLE'	/ binary table extension
BITPIX	=	8 / array data type
NAXIS	=	2 / number of array dimensions
NAXIS1	=	14 / length of dimension 1
NAXIS2	=	786432 / length of dimension 2
PCOUNT	=	0 / number of group parameters
GCOUNT	=	1 / number of groups
TFIELDS	=	5 / number of table fields
COMMENT		
COMMENT	*** End of mandatory fields ***	
COMMENT		
EXTVER	=	1 /Extension version
DATE	=	'2015-07-17' /Creation date
COMMENT		
COMMENT	*** Column names ***	
COMMENT		

```

COMMENT
COMMENT *** Column formats ***
COMMENT
COMMENT *** Column units ***
COMMENT
COMMENT *** Planck params ***
COMMENT
EXTNAME = 'COMP-MAP'           / Extension name
AST-COMP= 'CMB'                / Component
RESOLN  = 'NA'                 / arcmin
PIXTYPE = 'HEALPIX'           /
POLCCONV= 'COSMO'              / Polarization convention
COORDSYS= 'GALACTIC'           / Coordinate system
ORDERING= 'NESTED'             / Healpix ordering
NSIDE   = '256'                / Healpix Nside
FIRSTPIX=                      0 /
LASTPIX =                      786431
FILENAME= 'COM_CMB_IQU-smica_1024_R2.02_full.fits' / FITS filename
BAD_DATA= -1.63750E+30 / HEALPIX bad pixel value
METHOD   = 'smica'             / Separation method
PROCVER  = 'DX11'              / Product version
TTYPE1   = 'I_STOKES'
TFORM1   = 'E'
TUNIT1   = 'K_CMB'
TTYPE2   = 'Q_STOKES'
TFORM2   = 'E'
TUNIT2   = 'K_CMB'
TTYPE3   = 'U_STOKES'
TFORM3   = 'E'
TUNIT3   = 'K_CMB'
TTYPE4   = 'TMASK'
TFORM4   = 'B'
TTYPE5   = 'PMASK'
TFORM5   = 'B'
COMMENT
COMMENT -----
COMMENT CMB products from smica, coverage full
COMMENT -----
COMMENT For further details see Planck Explanatory Supplement at:
COMMENT http://wiki.cosmos.esa.int/planckpla2015
COMMENT -----

```

In []: