FITS

- Flexible Image Transport System
- Not only for images!
- File format to pack data+metadata
- Data: image, catalog, spectra, radio cube etc.
- Metadata: description of the data in style
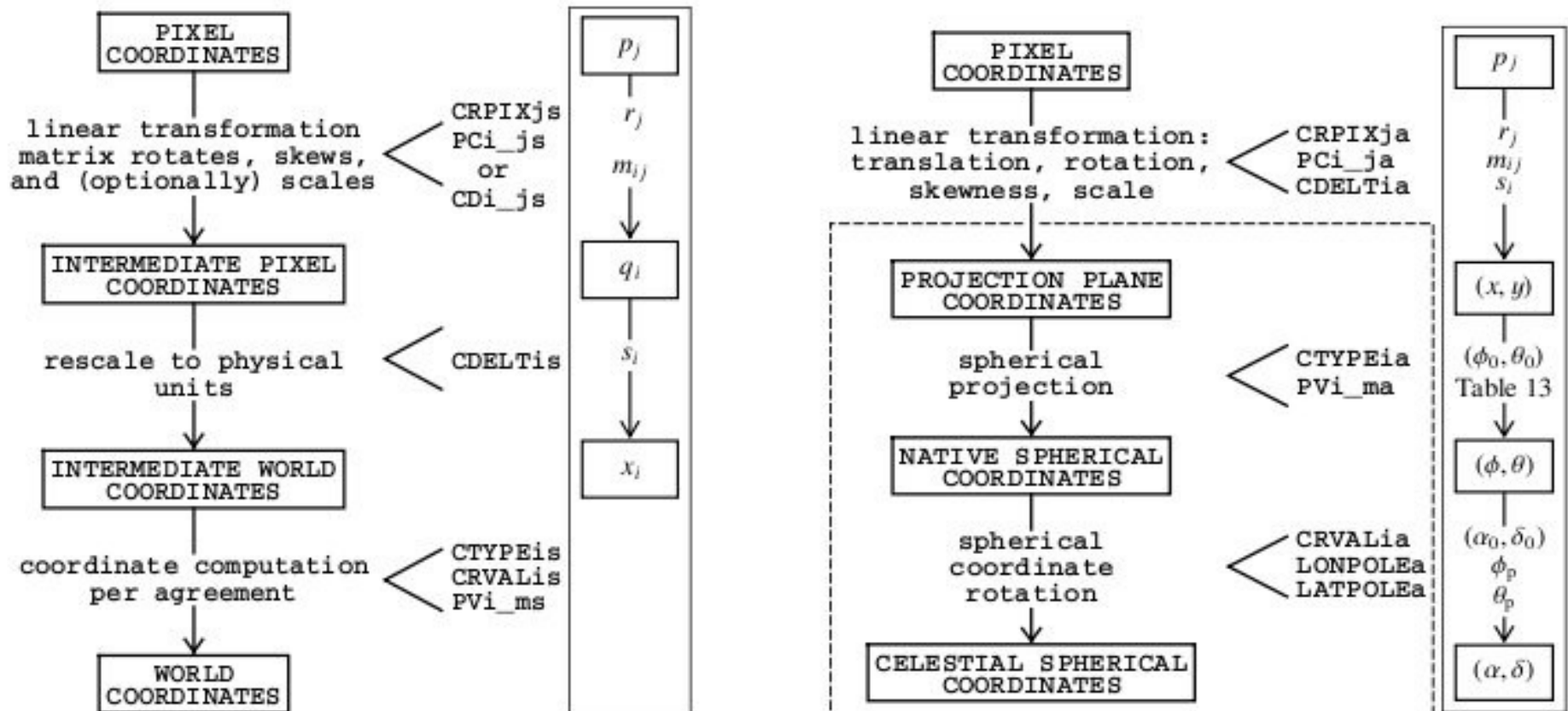
keyword=value

FITS structure

- HDU – Header/Data Units

- One header unit

- One or more data units

```
SIMPLE  =                              T / file conforms to FITS standard
BITPIX  =                             16 / number of bits per data pixel
NAXIS   =                              2 / number of data axes
NAXIS1  =                            440 / length of data axis 1
NAXIS2  =                            300 / length of data axis 2
```

FITS keywords

	CROTAn	EQUINOX	NAXISn	TBCOLn	TUNITn
AUTHOR	CRPIXn	EXTEND	OBJECT	TDIMn	TZEROn
BITPIX	CRVALn	EXTLEVEL	OBSERVER	TDISPn	XTENSION
BLANK	CTYPEn	EXTNAME	ORIGIN	TELESCOP	
BLOCKED	DATAMAX	EXTVER	PCOUNT	TFIELDS	
BSCALE	DATAMIN	GCOUNT	PSCALn	TFORMn	
BUNIT	DATE	GROUPS	PTYPEn	THEAP	
BZERO	DATE-OBS	HISTORY	PZEROn	TNULLn	
CDELTn	END	INSTRUME	REFERENC	TSCALn	
COMMENT	EPOCH	NAXIS	SIMPLE	TTYPEn	

World Coordinate System

Keyword	Use	Status	Comments
CRVALi	value at reference point	clarified	meaning of reference point forced by projection; no default.
CRPIXi	pixel of reference point	clarified	meaning of reference point forced by projection; no default.
CDELTi	increment at ref. point	clarified	meaning of reference point forced by projection; no default.
CROTAi	rotation at ref. point	deprecated	replaced by PCiiijjj.
CTYPEi	coordinate/projection type	clarified	for spherical coordinates, first 4 characters give "standard system" used in CRVALn, second 4 characters give type of projection as in Table 5; no default.
CUNITi	units of coordinate values	new	character-valued; keep it simple please; ignored for angles which are always degrees
PCiiijjj	coordinate increment	new	converts pixel number to pixels along true coordinates; default = 0(iii 6= jjj); = 1(iii = jjj).
CDiiijjj	coordinate increment	defined	synonym for PCiiijjj times CDELTn diagonal matrix; deprecated no default; -- should not be written
CDi j	coordinate increment	defined	synonym for PCiiijjj times CDELTn diagonal matrix; deprecated no default; -- should not be written
LONGPOLE	coordinate rotation	new	longitude in the native coordinate system of the standard system's North pole; default = 0ffi if ffi0 ? `0, = 180ffi otherwise.
LATPOLE	coordinate rotation	new	latitude in the native coordinate system of the standard system's North pole; default (= 999) equivalent given by Eq. 7 with + taken.
PROJPm	projection parameter m	new	parameters required in some projections, see Table 5; no default for m = 1, otherwise 0.
EPOCH	coordinate epoch	deprecated	replaced by EQUINOX.
EQUINOX	coordinate epoch	new	epoch of the mean equator and equinox in years; (Besselian if FK4, Julian if FK5; see Section 3 for defaults
MJD-OBS	date of observation	new	Modified Julian Date (JD - 2400000.5) of observation in days; default = DATE-OBS or, if missing, EQUINOX.
RADECSYS	frame of reference	new	string identifying the frame of reference of the equatorial coordinates; default = 'FK4' for EQUINOX < 1984:0 and 'FK5' for >= 1984:0
CmVALi	value at reference point	new	(m = 2; 3; : : :9) secondary coordinate for axis i; no default.
CmPIXi	pixel of reference point	new	secondary coordinate description; no default.
CmELTi	increment at ref. point	new	secondary coordinate description; no default.
CmYPEi	coordinate/projection type	new	secondary coordinate description; no default.
CmNITi	units of coordinate values	new	secondary coordinate description; no default except angles are in degrees.

```
Terminal                                                          _ □ ✕

File   Edit   View   Terminal   Tabs   Help

SIMPLE  =                      T / Fits format
BITPIX  =                    -32 / bits per pixel
NAXIS   =                      2 / single image
NAXIS1  =                   2442 / x size
NAXIS2  =                   4881 / y size
DATE-OBS= '2000-04-04T03:12:13' / no comment
FLXSCALE=     6.05223407986e-13 / no comment
OBJECT  = 'NGC3379_1          ' / no comment
ZEROPNT =          30.5452107082 / no comment
ZPNTERR =          1.00000827428 / no comment
INSTRUME= 'WFI               ' / no comment
TELESCOP= 'MPI-2.2           ' / no comment
TEL_LAT =              -29.2543 / no comment
TEL_LONG=              -70.7346 / no comment
TEL_ELEV=               2335.0 / no comment
TEL_ZONE=                  4.0 / no comment
CHIP_ID = 'ccd54            ' / no comment
FILT_ID = '#844             ' / no comment
CTYPE1  = 'RA---TAN          ' / no comment
CRVAL1  =            162.3913043 / no comment
CRPIX1  =              -10469.0 / no comment
CTYPE2  = 'DEC--TAN          ' / no comment
CRVAL2  =             12.44680851 / no comment
CRPIX2  =                2250.0 / no comment
CD1_1   =      -5.555555638e-05 / no comment
CD1_2   =                  0.0 / no comment
CD2_1   =                  0.0 / no comment
CD2_2   =       5.555555638e-05 / no comment
STATMIN =        -7183.23876953 / no comment
STATMAX =         57059.4921875 / no comment
STATMEAN=         537.706895159 / no comment
STATDEV =         397.969127936 / no comment
STATMED =         534.767578125 / no comment
OBS_DATE= '2000-04-04T03:12:13' / no comment
OBS_NAME= 'Unknown           ' / no comment
OBS_TYPE= 'Unknown           ' / no comment
OBS_ID  =                    -1 / no comment
OBS_PID = 'Unknown           ' / no comment
TPL_DATE= '2000-04-04T03:12:13' / no comment
TPL_NAME= 'Unknown           ' / no comment
TPL_PURP= 'Unknown           ' / no comment
TPL_NEXP=                     1 / no comment
DATAMD5 = '5200f9c357c532e6c2c6e1043e8e92be' / MD5 checksum
END

--More--
```
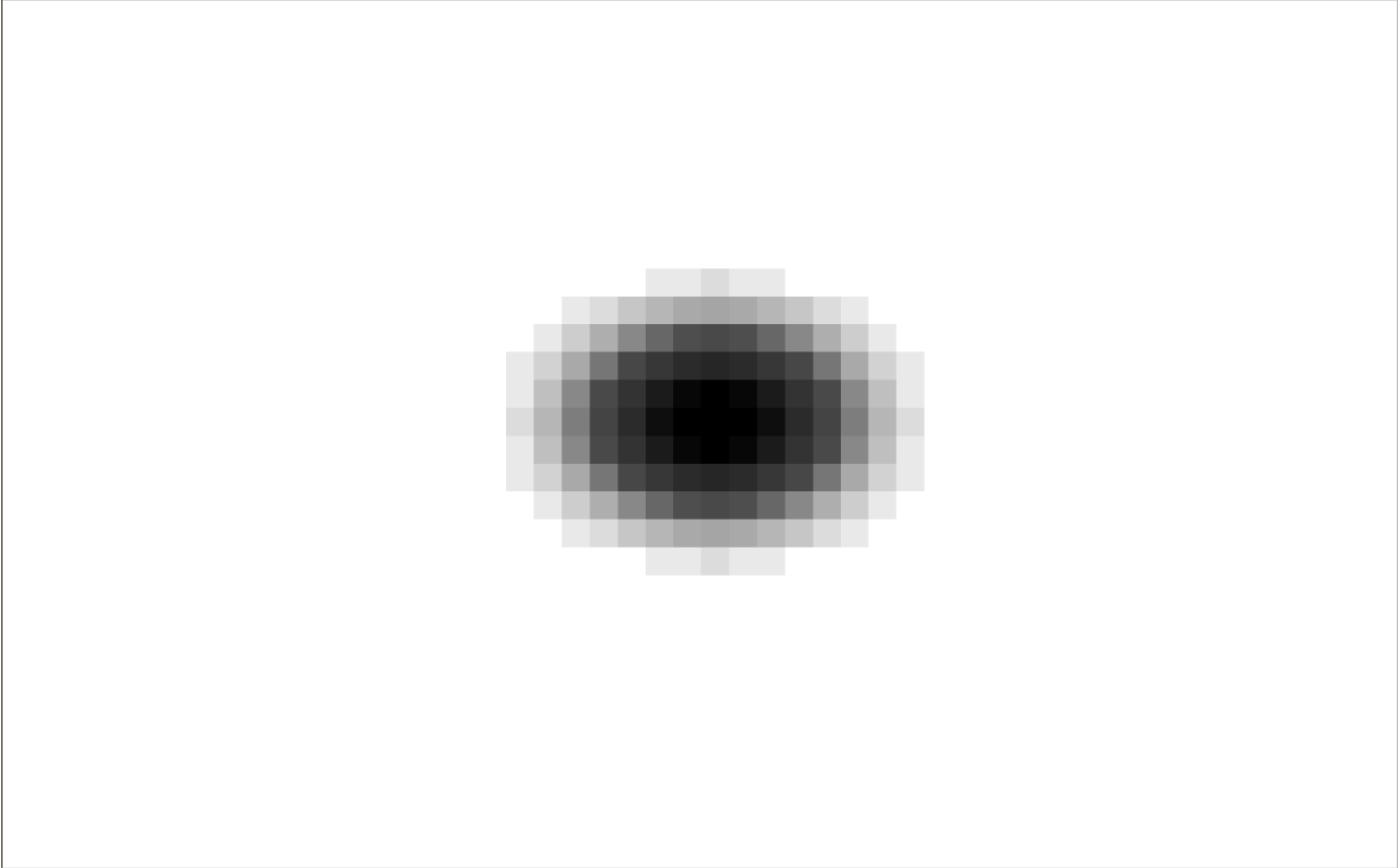
pyfits

- Open FITS file
- Operation with image as numpy array
- Write a new FITS file
- Create a FITS table

13.37' x 8.333'

FITS table

FITS format code	Description	8-bit bytes
L	logical (Boolean)	1
X	bit	*
B	Unsigned byte	1
I	16-bit integer	2
J	32-bit integer	4
K	64-bit integer	4
A	character	1
E	single precision floating point	4
D	double precision floating point	8
C	single precision complex	8
M	double precision complex	16
P	array descriptor	8

R: FITSio

- library(FITSio)

- FI<-readFITS("2MASSJ.fits")