Representations of Celestial Coordinates in FI

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Initial FITS Coordinate Specification

Keywords

`CTYPE`*n* Coordinate type (8 characters)
`CRPIX`*n* Reference pixel location
`CRVAL`*n* Coordinate value at reference pixel
`CDELT`*n* Coordinate increment at reference pixel
`CROTA`*n* Coordinate "rotation"

Problems with this

- Types inadequate for celestial coordinates, velociti
- Physical meaning of reference pixel undefined
- Rotation undefined, inadequate for general use
- No provision for skew in images

AIPS enhancements

- Types defined for some celestial coordinates, veloc
- Reference pixel defined as tangent point
- Rotation limited to celestial coordinates
- Still no skew or offset rotations
- Limited view of projective geometries

Proposed FITS Coordinate Specification

Keywords for All Coordinate Types

CDn_m = CD$nnnmmm$ Matrix

- Replaces CDELTn and CROTAn keywords
- Allows skew, offset and general rotations
- Allows dissimilar coordinates to be rotated togetl
- Relative coordinates given by linear transform :

$$\begin{pmatrix} x \\ y \\ z \\ \vdots \end{pmatrix} = \begin{pmatrix} \texttt{CD1\_1} & \texttt{CD1\_2} & \texttt{CD1\_3} & \dots \\ \texttt{CD2\_1} & \texttt{CD2\_2} & \texttt{CD2\_3} & \dots \\ \texttt{CD3\_1} & \texttt{CD3\_2} & \texttt{CD3\_3} & \dots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} \begin{pmatrix} i - i_0 \\ j - j_0 \\ k - k_0 \\ \vdots \end{pmatrix}$$

Proposed FITS Coordinate Specification

Keywords for Celestial Coordinates

`CTYPE`n format defined

- First 4 characters give type of "standard coordinate sys
  equatorial — `RA--` and `DEC-`
  galactic — `GLON` and `GLAT`
  ecliptic — `ELON` and `ELAT`
- Second 4 characters give type of projection as `-`ccc
  where ccc defined by convention, such as
  `SIN`, `TAN`, `ARC`, `AIT`

`CRPIX`n meaning defined by projection

- Each projection has "native coordinate system "
- Reference pixel is native north pole $(0, 90°)$ for
  azimuthal and conical projections
- Reference pixel is native origin $(0, 0)$ for
  cylindrical and conventional projections

Proposed FITS Coordinate Specification

Celestial Coordinates Continued

CRVALn clarified

- Value in standard coordinates at the reference pixe
- LONGPOLE keyword added for generality
  Native longitude of north pole of standard syste
  Default value is 180°

PROJPj keywords added to define some projecti

Astrometry-related keywords added

- EQUINOX replaces EPOCH for the epoch of the mea
  equator and equinox in years
- MJD-OBS modified Julian date of observation in da
- RADECSYS frame of reference of equatorial coordin
  as FK4, FK4-NO-E, FK5, GAPPT

Proposed FITS Coordinate Specification

Conventions and Matters of "Good Form"

1. The center of each pixel is its location.
2. Default viewing convention:
   - First pixel at lower left corner,
   - First axis displayed along horizontal,
   - Second axis displayed along vertical.
3. Diagonal elements of `CD`i`_`j should predominate.
   - Do not hide transpositions in the `CD` matrix.
4. Forbid rotation into axes which have only integral valu
5. `NCP` projection (of WSRT) changed to offset `SIN` proje
6. When possible, `CDELT`n should be written along with
7. For longitude axis i and latitude axis j, the conversion

$$\begin{pmatrix} \texttt{CD}i\texttt{\_}i & \texttt{CD}i\texttt{\_}j \\ \texttt{CD}j\texttt{\_}i & \texttt{CD}j\texttt{\_}j \end{pmatrix} = \begin{pmatrix} \texttt{CDELT}i\cos(\texttt{CROTA}j) & -\texttt{CDELT}j\sin(\texttt{CROT} \\ \texttt{CDELT}i\sin(\texttt{CROTA}j) & \texttt{CDELT}j\cos(\texttt{CROT} \end{pmatrix}$$