APPLYING OF FITS FORMAT

Trunova T.O., *student, MST department, NURE*
Vovk A.V., *asst. prof., MST department, NURE*

The special software for processing and printing images (for example, CorelDRAW, Adobe Photoshop, Adobe Illustrator, etc.) is usually used in the printing industry. This software supports formats such as JPEG, PNG, PDF, GIF, but these formats do not cover all areas of the images receiving (creating). One of these formats is the FITS format, which is used in astronomy. Images of this format cannot be viewed, processed or printed using the basic programs for viewing and processing.

FITS format (Flexible Image Transport System) is a digital file format used for the storing and transmitting different images and their metadata (spreadsheets, binary tables) [1]. Usually the FITS format is used to exchange and archive astronomical data. It is supported by the International Astronomical Union (IAU), NASA and other national and international organizations involved into astronomy and related areas.

This format is often used to store data without images, such as spectra, photon lists, data cubes, arrays of brightness, or even structured data, such as databases with multiple tables. The FITS format includes many provisions for describing photometric and spatial calibration, as well as metadata of the image's origin.

The FITS format has a number of advantages that are not available for the often used JPEG and PNG formats. The following advantages are more crucial for scientific data:

– storing of more bits per pixel (CCD can write 8, 16, 32 or more bits), as well as floating point values;

– storing of any number of data channels (scientific data can have many channels or other frequency bands that differ than RGB, which JPEG and PNG are limited to);

– there is no lossy compression, as is usually (although not necessarily) for JPEG;

– higher resolution (for example, JPEG is limited to 65535 pixels in each direction), while FITS can also store volumes of 3D data;

– support of an unlimited amount of metadata in the header, for example, sky coordinates, information about the telescope, camera, etc., while JPEG and PNG do not have any fields and are not configured to store any metadata.

Unlike to other image formats, FITS is designed specifically for scientific data and therefore includes metadata about photometry and astrometry information, along with the original image data such as array of brightness.

The FITS file consists of one or more segments Header + Data Units called HDUs, where the first HDU is called the «Primary HDU» or «Primary Array» [2]. The primary data array can contain a 1-999-dimensional array of 1-, 2- or 4-byte integer numbers or 4- or 8-byte floating point numbers using IEEE representations. A typical primary array can contain a 1-D spectrum, a 2-D image, or a 3-D data cube.

Any number of additional HDUs should follow the main array. These additional HDUs are called FITS extensions. Three types of standard extensions are currently defined:

– image extensions contain an array of pixels with size of 0-999, similar to the primary array;

– extensions of ASCII tables store tabular information with all numeric information stored in ASCII formats;

– extensions of binary table store tabular information in binary representation.

Although ASCII tables are generally less efficient than the binary tables, so they can be made relatively human readable and can store numeric information with almost any size and accuracy (for example, 16-byte or even 32-byte values).

Each cell in the binary table should be an array, but the dimension of the array must be constant in the column. The strict standard supports only one-dimensional arrays, but agreement on support of the multi-dimensional arrays is widespread [3].

Each HDU consists of a «header block» in ASCII format, followed by an optional «data block». Each header block or data block (unit) is a multiple of 2880 bytes. If necessary, the header or data block is supplemented to the required length using ASCII or NULL spaces depending on the block type.

Each header block contains a sequence of 80-character fixed-length keyword records that have a common form: KEYNAME = value (number/string) / comment (string), for example:

DATE-OBS= '2019-01-08T07:28:35' / [ISO 8601] UTC date/time of exposure start

The last keyword in header block should always be the «END» keyword, which has empty both field value and comment.

The data block, if present, follows the last 2880-byte block in the header block. Some files do not require a data block, so some HDUs contain only a header block.

The conducted research shows that for processing or printing the FITS format images should be converted to PNG format images and then processed using the common image processing programs or mathematical methods for the image processing.

References

1. FITS Support Office. URL: https://fits.gsfc.nasa.gov.

2. Wells D.C., Greisen E.W., Harten R.H. FITS – a Flexible Image Transport System // Astronomy and Astrophysics Supplement. 1981. Vol. 44. P. 363.

3. Allegrezza S. Flexible Image Transport System: a new standard file format for long-term preservation projects // European Week of Astronomy and Space Science. 2012. P. 1-6.