



SPICAM/SPICAV project

Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars
Spectroscopy for Investigation of Characteristics of the Atmosphere of Venus

Using SPICAM and SPICAV UV 1A level data

LATMOS-SPI-UD-001

Release 3

05 November 2014

Prepared by:

Nicolas Chapron (LATMOS)

Approved by:

Gaetan Lacombe (LATMOS)

Release history

Release	Date	Comments
1	31/05/2012	First release
1.1	07/06/2012	Add part 3 FORTRAN
2	07/02/2013	Update sections 2 and 4
2.1	02/04/2014	Reformatted, FLAG mask update
3	05/11/2014	Update to match with the IR documentation format

Table of contents

1. Introduction	4
1.1 Purpose	4
1.2 Reference documents	4
1.3 Abbreviations	5
2. Brief description of the data	6
3. Data structure description	8
1.4 Primary block: CLEANDATA	8
1.5 Extension 1: FLAG	9
1.6 Extension 3: ERRDATA	10
1.7 Extension 4: PARAMETERS	10
1.8 Extension 4-14: GEOMETRY	11
1.8.1 Extension 4: GEO_RECORDS	12
1.8.2 Extension 5: GEO_SPACECRAFT	12
1.8.3 Extension 6: GEO_BAND3	13
1.8.4 Extension 7: GEO_COORDINATES	14
1.8.5 Extension 8: GEO_TRANSMATRIX	15
1.8.6 Extension 9-12: GEO_BAND[1 2 4 5 CCDLIN]	15
1.8.7 Extension 13: GEO_LOSE	15
4. Proposed reading software	16
1.9 IDL	16
1.9.1 Installation and execution	16
1.9.2 Returned Structure	16
1.9.3 Example of use	16
1.10 FORTRAN	17
1.10.1 Building the CFITSIO library	17
1.10.2 Installation and execution	17
1.10.3 Returned Structure	18
1.11 C	18
1.11.1 Installation and execution	18
1.11.2 Returned Structure	19

1. Introduction

1.1 Purpose

This document provides a description of the cleaned SPICAM and SPICAV UV data, which is named the level 1A data. The purpose is to give the users, essential information about the format and the content of the data.

1.2 Reference documents

Ref N°	Title	Author	Date
1	SPICAM on Mars Express: Observing modes and overview of UV spectrometer data and scientific results, Journal of Geophysical Research, Volume 111, E10S90	Bertaux et al.	2006
2	SPICAV on Venus Express: Three spectrometers to study the global structure and composition of the Venus atmosphere, Planetary and Space Science, Volume 55, Issue 12, p. 1673-1700	Bertaux et al.	2007

1.3 Abbreviations

ADU	Analog to Digital Unit
DC	Dark Current
DCNU	Dark Current Non Uniformity
EN	Electronic Noise
FITS	Flexible Image Transport System
FOV	Field Of View
HDU	Header Data Unit
IR	Infrared
LOS	Line Of Sight
MEX	Mars Express spacecraft
NaN	Not a Number
SPICAM	Spectroscopy for Investigation of Characteristics of the Atmosphere of Mars
SPICAV	Spectroscopy for Investigation of Characteristics of the Atmosphere of Venus
UV	Ultraviolet
VEX	Venus Express spacecraft

2. Brief description of the data

The SPICAM and SPICAV 1A data files are built from the 0C level files. The 1A level provides data corrected from the dark charge and the electronic noise. It is also cleaned from erroneous data (only SPICAM), cosmic rays damage and saturation.

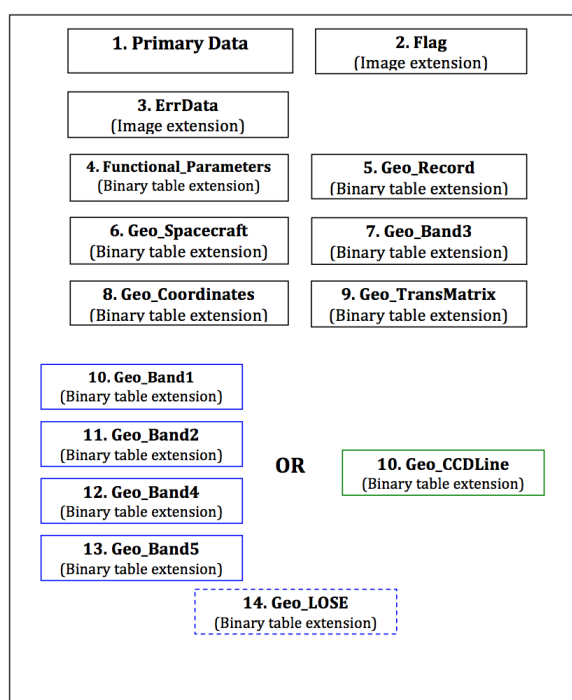
The 1A level files are under FITS (Flexible Image Transport System) format and conform to the requirements of the FITS standard. For a general introduction of FITS format please follow the link: http://fits.gsfc.nasa.gov/fits_documentation.html

A FITS file is made of several data blocks, which are named as Header Data Units (HDUs). The file contains a primary data block and several extensions, which can be an Image Extension (multi-dimensional array of pixels, similar to a primary data block) or a Binary Table Extension (tabular information in a binary representation which contain multi-dimensional arrays).

Since the 1A level is based on the 0C level, the files follow the same FITS structure with updates and additions.

The 1A level FITS files contain the following modules:

- **Primary**: 3D image. It corresponds to the 1A level data.
- **Flag**: 3D image extension. It corresponds to the flag associated to each pixel of the Primary data.
- **ErrData**: 3D image extension. It corresponds to the error from the Dark Charge and Electronic Noise removal process on each pixel.
- **Functional_Parameters**: binary table extension. This extension contains functional parameters (telecommand) information and temperatures.
- **Geo_*** binary: table extensions (from 6 to 10 depending on the observation type and mode, example: *Geo_Spacecraft*). Each of these extensions contains the geometrical parameters record associated.



SPICAM/V UV 1A FITS files block diagram

The development team provides a reading program, based on the IDL, FORTRAN and C languages. It can be found in the directories:

/net/nfs/spicam/data/ARCHIVE/SOFTWARE/1A/

/net/nfs/spicav/data/ARCHIVE/SOFTWARE/1A/

NB: those distributions are identical; the reading program is able to read both SPICAM and SPICAV 1A UV files as they share the same format.

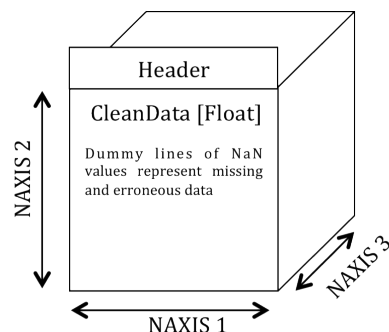
The section 4 explains how to use the program. Note that any other common languages can read the FITS files.

3. Data structure description

1.4 Primary block: CLEANDATA

This field represents the primary block of the FITS data and it contains the data corrected from the saturation, the cosmic rays, the dark charge and the electronic noise. The name given in the FITS file is *CLEANDATA*. This field is a 3 dimensions (naxis1, naxis2, naxis3) float array with dimensions depending on the observation mode:

- For a general case 5-band observation, the dimensions of the array are:
[NB_PIXELS=408, NB_SPECTRUM, NB_BANDS=5]
- For an Alignment mode observation the dimensions are:
[NB_PIXELSX=408, NB_PIXELSY=289, NB_IMAGES]
- Window mode dimensions are:
[XWIDTH, YWIDTH, NB_RECORDS]



Mode	NAxis1	NAxis2	NAxis3
<i>5 bands</i>	408	Number of records	5
<i>Alignment</i>	408	289	Number of reconstituted images
<i>Window</i>	Window width	Window length	Number of records

The header of the primary block is the main header of the data; it contains general information about the observation data. All the parameters are described in the following table:

PARAMETERS	TYPE	DESCRIPTION
NAXIS1	INTEGER	Number of pixels of the X-axis of the CCD, i.e. number of points of each spectrum = 408 except for window mode
NAXIS2	INTEGER	Number of 5-band spectra recorded throughout observation. For alignment observation this field corresponds to the number of pixels of the Y-axis of the CCD = 289. For Window modes, it is the vertical width
NAXIS3	INTEGER	Number of bands of the CCD = 5. For alignment observations this is equal to the number of complete mapping of the CCD. For Window mode this is equal to the number of records
INSTRU	STRING	Name of the instrument
ORBIT	INTEGER	Orbit number
SEQ_NB	INTEGER	Sequence number
OBSTYPE	STRING	Type of observation as defined by SPICAM/V convention
BEGINS	STRING	UTC time of the first record of the observation, format="YYYY-MM-DDThh:mm:ss.ms"
ENDS	STRING	UTC time of the last record of the observation, format="YYYY-MM-DDThh:mm:ss.ms"

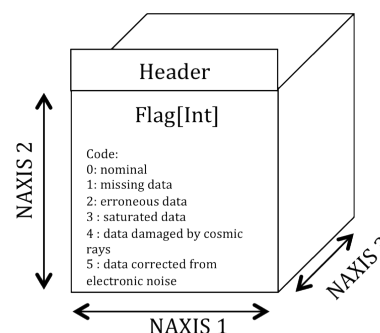
DATA_0A	STRING	Name of the 0A data file source
DATA_GEO	STRING	Name of the Geometry file source
DATA_0C	STRING	Name of the 0C data file source
FLAG	STRING	Name of the flag data file source
DATA_SS	STRING	Data status (F "Final" or "P" Preliminary)
GEO_SS	STRING	Geometry status (F "Final" or "P" Preliminary)
FLAG_SS	STRING	Flag status (F "Final" or "P" Preliminary)
COSPROC	BOOLEAN	Cosmic rays removal process (0: not done - 1: done)
SATPROC	BOOLEAN	Saturation removal process (0: not done - 1: done)
DCPROC	BOOLEAN	Dark Charge removal process (0: not done - 1: done)
ENPROC	BOOLEAN	Electronic Noise removal process (0: not done - 1: done)
ORBDCNU	INTEGER	Orbit of the DCNU model

1.5 Extension 1: FLAG

This field is a 3 dimensions integer array with the same dimension as the primary block. It corresponds to the flag matrix of the data; it contains a flag value associated to each pixel of the primary image.

The Flag code convention is defined as below:

- 0: nominal (flagged by pixel)
- 1: missing data (flagged by spectrum (record) line)
- 2: erroneous data (flagged by spectrum (record) line)
- 3: saturated data (flagged by pixel)
- 4: data damaged by cosmic rays (flagged by pixel)
- 5: data corrected from electronic noise (flagged by pixel)



This array is a mask that the user should apply on the CLEANDATA array. If applied, the missing records, the erroneous data, the saturated pixels and the pixels damaged by the cosmic ray are set to NaN¹ value.

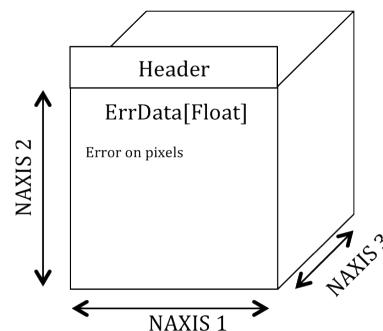
This extension has the following specific header fields:

PARAMETER	TYPE	DESCRIPTION
NB_ERR	INTEGER	Number of spectra (complete line) detected as erroneous (flag code 2).
NB_MISS	INTEGER	Number of dummy lines injected (complete line) because of missing data (flag code 1)
NB_SAT	INTEGER	Number of detected and cleaned saturated pixels (flag code 3)
NB_COS	INTEGER	Number of detected and cleaned cosmic rays damaged pixels (flag code 4)

¹ NaN: Not a Numer, data type representing an undefined value, IEEE 754 standard

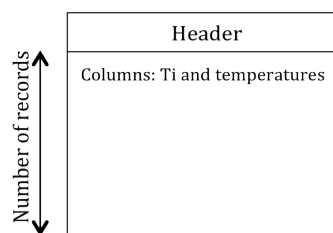
1.6 Extension 3: ERRDATA

This field is a 3 dimensions float array with the same dimension as the primary block. It contains the error value on Dark Charge and Electronic Noise corrections associated to each pixel of the primary image.



1.7 Extension 4: PARAMETERS

This extension is a Binary Table and contains vectors corresponding to the functional parameters of the instrument during the observation. For 5-bands observations the "All_Ti" and "T_..." fields are a 1D-length array with size equal to the number of spectra. For alignment modes they are 1D-length array with size equal to $[NB_PIXELSY=289, NB_IMAGES]$.



The following table describe each parameters of the table:

PARAMETER	TYPE	DESCRIPTION	UNIT
ALL_TI	FLOAT	Vector of all the time exposure throughout the observation	
T_PELTIER	FLOAT	Temperature vector of Peltier's hot side	°C
T_CCD	FLOAT	Temperature vector of the CCD	°C
T_NUMBOARD	FLOAT	Temperature vector of the digital board	°C
T_BTBOARD	FLOAT	Temperature vector of the low tension board	°C
T_SHUTTER	FLOAT	Temperature vector of the solar shutter	°C
T_SERVBOARD	FLOAT	Temperature vector of the servitudes board	°C
T_HVPS	FLOAT	Temperature vector of the High Voltage Power Supply	°C
T_STRUCTURE	FLOAT	Temperature vector of the structure	°C

The header of this extension contains scalar numbers corresponding to the functional parameters of the instruments programmed for the observation:

PARAMETER	TYPE	DESCRIPTION
CODEOP	INTEGER	UV operation code
BINNING	INTEGER	Number of lines binned together to form a band. In case of progressive binning, the field is set to string 'VARIABLE'
X0	INTEGER	X-axis first pixel index
Y0	INTEGER	Y-axis first pixel index. Field is set to 'VARIABLE' for alignment observations
HT	INTEGER	Digital scale of the High Voltage used to amplify signal. Ranging from 0 to 255
TI	INTEGER	Exposure Time of the CCD, in second/100. Usually constant throughout observation. If not the field is set to string 'VARIABLE'
SLIT	BOOLEAN	1 if slit is on, 0 else.
PELTIER	BOOLEAN	1 if peltier cooler is on, 0 else
UVSAMPLING	INTEGER	Sample rate of the spectrometer
IRON	BOOLEAN	1 if IR channel is on, 0 else
SOIR_ON	INTEGER	1 if SPICAV SOIR channel is on, 0 else. 255 for SPICAM

1.8 Extension 4-14: GEOMETRY

The geometry data is defined in several different Binary Table extensions. All the information are directly extracted from the 0A level geometry file and rearranged in a structured way. The geometry content depends on the observation mode:

- Extensions for all modes:
 - RECORD: structure array containing the time and number of each record
 - SPACECRAFT: structure array containing geometrical information relative to the SC
 - BAND3: structure array containing geometrical information relative to the central band
 - COORDINATES: structure array containing the SC coordinates in different referential
 - TRANSMATRIX: structure array of the transformation matrix coordinates from the local referential to EMEJ2000
- Extensions specific to the 5 bands mode:
 - BAND1: structure array containing geometrical information relative to the 1st band
 - BAND2: structure array containing geometrical information relative to the 2nd band
 - BAND4: structure array containing geometrical information relative to the 4th band
 - BAND5: structure array containing geometrical information relative to the 5th band
 - LOSE: structure array containing geometrical information relative to the specific star pointing line of sight (if present in the 0A level geometry file), see Annex1.
- Extension specific to the Alignment mode:
 - CCDLINE: structure array containing geometrical information relative to each particular CCD line

The dimension of the geometry array depends also on the observation mode

Mode	Structure array dimensions
<i>5 bands</i>	Vector of length NAXIS2
<i>Alignment</i>	Matrix of size [NAXIS2, NAXIS3]
<i>Window</i>	Vector of length NAXIS3

1.8.1 Extension 4: GEO_RECORDS

This extension is an array containing the time of a beginning of block record with fixed time interval of delivery.

The two table parameters are:

<i>PARAMETER</i>	<i>TYPE</i>	<i>DESCRIPTION</i>
NUMBER	INTEGER	Record number
TIME	STRING	UTC time of the record, format="YYYY-MM-DDThh:mm:ss.ms"

The header of this extension contains geometrical parameters of the instrument which do not vary during observation:

<i>PARAMETER</i>	<i>TYPE</i>	<i>DESCRIPTION</i>	<i>UNIT</i>
TARGET	STRING	Pointed target (For stars, see SPICAM/V star catalog)	
SUNLAT	FLOAT	Sub-solar point latitude in planet body-fixed frame, at first record	Deg.
SUNLONG	FLOAT	Sub-solar point longitude in planet body-fixed frame, at first record	Deg.
SUNDIST	FLOAT	Distance between planet and sun, at first record	U.A.
SUNLS	FLOAT	Planet position seen from the Sun in Ecliptic J2000 frame	Deg.
SUNRA	FLOAT	Sun Right Ascension in J2000 frame, at first record	Deg.
SUNDEC	FLOAT	Sun Declination in J2000 frame, at first record	Deg.
SLIT_C	FLOAT ARRAY	Slit center position vector (theta, phi) in the spacecraft referential	Deg.
SHADOWCONE	STRING	Trajectory of the spacecraft relatively to the planet shadow cone	

1.8.2 Extension 5: GEO_SPACECRAFT

This extension is a table containing some geometrical information relative to the Mars Express or Venus Express spacecraft:

<i>PARAMETER</i>	<i>TYPE</i>	<i>DESCRIPTION</i>	<i>UNIT</i>
LAT	FLOAT	Latitude of the sub-spacecraft point (in degrees, body-fixed frame)	Deg.
LONG	FLOAT	Longitude of the sub-spacecraft point (in degrees, increases toward East from 0 to 360, body-fixed frame)	Deg.
ALT	FLOAT	Altitude of the spacecraft above planet ellipsoid (in km, body-fixed frame)	Deg.
SZA	FLOAT	Solar Zenith Angle at sub-spacecraft point (in degrees, body-fixed frame)	Deg.
SHADOWCONERATIO	FLOAT	Ratio indicating the SC position relative to the planet's shadow cone. If >1 SC is outside the shadow cone.	

1.8.3 Extension 6: GEO_BAND3

This extension is a table containing all the geometrical information relative to the central band. For all kind of observations, the line of sight (LOS) emanating from the center of a UV band is defined by SC attitude. The parameters in **BLUE** are specific to the 5-band mode, and are common to the extension GEO_BAND1-3.

In the case of star observations, geometry parameters are also computed for a LOS emanating from the UV CCD center, but defined by S/C position and Star direction. (This LOS is called LOSE in the following description of parameters to distinguish from LOS defined by SC attitude), these specific parameters are stored in the extension GEO_LOSE.

PARAMETER	DESCRIPTION	UNIT
LAT	Latitude of nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS)	Deg.
LONG	Longitude of nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS)	Deg.
ALT	Altitude above the nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS, < 0 IF intersection)	Km.
RA	Right ascension of LOS/LOSE emanating from the center of CCD (3rd band) (EMEJ2000)	Deg.
DEC	Declination of LOS/LOSE emanating from the center of CCD (3rd band) (EMEJ2000)	Deg.
SZA	Solar zenith angle at nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS)	Deg.
DISTTOPLANETNP	Distance from MEX/VEX to nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS, < 0 if behind SC)	Km.
PIXELSIZE	Pixel (0.01 deg) size at nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS)	Km.
ANGLELOSSUN	Angle between S/C-SUN vector and LOS emanating from the center of CCD (3rd band) (IAU_MARS/IAU_VENUS)	Deg.
PHASELOSSUN	Phase angle between the SUN and the Observer measured at the nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band)	Deg.
SOLARINCIDENCE	Solar incidence angle between SUN and Normal at nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band)	Deg.
SOLARLOCALTIME	Solar local time at nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band)	Deg.
ANGLENORMALOBSERVER	Emission angle between Normal and Observer at nearest point on MARS/VENUS ellipsoid to LOS/LOSE emanating from the center of CCD (3rd band)	Deg.
SUNAZIMUTH	Azimuth of SUN in MEX/VEX axes (relative to X)	Deg.
DISTLOSPLANETCENTER	Distance between the nearest point on LOS/LOSE emanating from the center of CCD (3rd band) and center of MARS/VENUS	Km.
DISTSCPLANETCENTER	Distance between MEX/VEX position and center of MARS/VENUS	Km.

1.8.4 Extension 7: GEO_COORDINATES

This extension is a table containing all the Mars Express or Venus Express spacecraft coordinates in different referential:

PARAMETER	DESCRIPTION
XSC_X	X component of the unit inertial pointing vector (1,0,0) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
XSC_Y	Y component of the unit inertial pointing vector (1,0,0) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
XSC_Z	Z component of the unit inertial pointing vector (1,0,0) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
YSC_X	X component of the unit inertial pointing vector (0,1,0) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
YSC_Y	Y component of the unit inertial pointing vector (0,1,0) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
YSC_Z	Z component of the unit inertial pointing vector (0,1,0) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
ZSC_X	X component of the unit inertial pointing vector (0,0,1) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
ZSC_Y	Y component of the unit inertial pointing vector (0,0,1) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
ZSC_Z	Z component of the unit inertial pointing vector (0,0,1) in SC coordinates relative to MARSIAU (SPICAM) or IAU_VENUS (SPICAV) frame
ANGLE_XSC_LOCALVERT	Angle between the S/C X axis and the local vertical at the planet Nearest Point (in degrees)
ANGLE_XSC_PROJ	Angle between the projection plane U axis and the S/C X axis projected on this plane (in degrees)
P1_u	P1 u horizon point component in <i>Planproj</i>
P1_v	P1 v horizon point component in <i>Planproj</i>
P2_u	P2 u horizon point component in <i>Planproj</i>
P2_v	P2 v horizon point component in <i>Planproj</i>
P3_u	P3 u horizon point component in <i>Planproj</i>
P3_v	P3 v horizon point component in <i>Planproj</i>
P4_u	P4 u horizon point component in <i>Planproj</i>
P4_v	P4 v horizon point component in <i>Planproj</i>
P5_u	P5 u horizon point component in <i>Planproj</i>
P5_v	P5 v horizon point component in <i>Planproj</i>

All parameters are floating numbers.

Planproj is the projection plane (u,v,w frame) defined as the plane at the nearest point on the planet to vdir and perpendicular to vdir (view direction from SC); with $w = -vdir$, $v = \text{North pole}$, $u = \text{right handed}$.

1.8.5 Extension 8: GEO_TRANSMATRIX

This extension is a table containing the transformation matrix coordinates from the local referential to EMEJ2000:

PARAMETER	DESCRIPTION
X_Ra	X Ra component of transformation matrix from MARSIAU (SPICAM) or IAU_VENUS (SPICAV) to EMEJ2000
X_Dec	X Dec component of transformation matrix from MARSIAU (SPICAM) or IAU_VENUS (SPICAV) to EMEJ2000
Y_Ra	Y Ra component of transformation matrix from MARSIAU (SPICAM) or IAU_VENUS (SPICAV) to EMEJ2000
Y_Dec	Y Dec component of transformation matrix from MARSIAU (SPICAM) or IAU_VENUS (SPICAV) to EMEJ2000
Z_Ra	Z Ra component of transformation matrix from MARSIAU (SPICAM) or IAU_VENUS (SPICAV) to EMEJ2000
Z_Dec	Z Dec component of transformation matrix from MARSIAU (SPICAM) or IAU_VENUS (SPICAV) to EMEJ2000

All parameters are floating numbers

1.8.6 Extension 9-12: GEO_BAND[1|2|4|5|CCDLINE]

These extensions are tables containing the geometrical information relative to the center of band_nb (1, 2, 4 or 5 for extensions GEO_BAND1/2/4/5) or the CCD line (from 1 to 289 for each images, for extension GEO_CCDCLINE).

PARAMETER	DESCRIPTION	UNIT
LAT	Latitude of nearest point on MARS/VENUS ellipsoid to LOS emanating from the center of band_nb/line (IAU_MARS/IAU_VENUS)	Deg.
LONG	Longitude of nearest point on MARS/VENUS ellipsoid to LOS emanating from the center of band_nb/line (IAU_MARS/IAU_VENUS)	Deg.
ALT	Altitude above the nearest point on MARS/VENUS ellipsoid to LOS emanating from the center of band_nb/line (IAU_MARS/IAU_VENUS, < 0 IF intersection)	Km.
RA	Right ascension of LOS emanating from the center of band_nb/line (EMEJ2000)	Deg.
DEC	Declination of LOS emanating from the center of band_nb/line (EMEJ2000)	Deg.

1.8.7 Extension 13: GEO_LOSE

This extension is specific for star occultation observation. It contains the same parameters as GEO_BAND3 extension, computed with the specific LOS definition. Please refer to the section 1.8.3.

4. Proposed reading software

1.9 IDL

1.9.1 Installation and execution

The IDL software package is located in the directories:

```
/net/nfs/spicam/data/ARCHIVE/SOFTWARE/1A/IDL/
/net/nfs/spicav/data/ARCHIVE/SOFTWARE/1A/IDL/
```

Download and package in your working directory. Compile the procedures. The function `SPICA_Read_1A` takes for argument the filename of the 1A file to read and returns a structure variable. The `SILENT` keyword can be added to avoid printing the reading confirmation.

IMPORTANT: The `FLAG` mask is applied by default. It means that the data with a flag value equal to 1, 2, 3 or 4 are removed and set to NaN. The keyword `/NO_MASK` can be used to keep the data flagged in the `CLEANDATA` array.

1.9.2 Returned Structure

The IDL structure returned by the software contains several variables. Each variables match to one or several specific FITS blocks, except for the *Infos* sub-structure, which contains the parameters from the main data header. The *Geo* structure contains all the content from extension 4 to 14.

<i>VARIABLE</i>	<i>TYPE</i>
CLEANDATA	FLOAT ARRAY [NAXIS1, NAXIS2, NAXIS3]
FLAG	FLOAT ARRAY [NAXIS1, NAXIS2, NAXIS3]
ERRDATA	FLOAT ARRAY [NAXIS1, NAXIS2, NAXIS3]
INFO	STRUCT
PARAMETERS	STRUCT
GEOINFO	STRUCT
GEO	STRUCT
GEOUNITS	STRUCT

1.9.3 Example of use

- Read a SPICAM 1C file located in *IPath* into *obs* variable:

```
IDL>obs=SPICA_Read_1A('/IPath/SPIM_1AU_02697A01_E_01.FITS')
The file SPIM_1AU_02697A01_E_01.FITS was read successfully!
```

- Create a window with the size of the data and plot the clean data central band:

```
IDL> window,0,XSIZE=obs.info.naxis1,YSIZE=obs.info.naxis2
IDL> loadct,39
IDL> TVIMAGE, obs.cleandata[*,*,2]
```

- Plot the error data on central band:

```
IDL> Window,1,XSIZE=obs.info.naxis1,YSIZE=obs.info.naxis2
IDL> TVIMAGE, obs.errdata[*,*,2]
```

1.10 FORTRAN

1.10.1 Building the CFITSIO library

The 1A reading software provided uses the *cfitsio* library for reading FITS format data files. This library package can be found at:

<http://heasarc.gsfc.nasa.gov/docs/software/fitsio/fitsio.html>

To build the library, the user should:

- Download and uncompress the *cfitsio* package for your system.
- Build the *cfitsio* library in local, by launching the *makefile* (see README file in the *cfitsio* directory for building information).
- The result of building the library is the creation of the file: ***libcfitsio.a*** in the *cfitsio* directory.

For Unix-like systems, the simple launch of the *makefile* permits to build easily the library. For Windows systems, a unix-like emulator system such as *Cygwin* can be used to launch this *makefile*.

1.10.2 Installation and execution

The FORTRAN software package is located in the directories:

/net/nfs/spicam/data/ARCHIVE/SOFTWARE/1A/FORTRAN/
/net/nfs/spicav/data/ARCHIVE/SOFTWARE/1A/FORTRAN/

The package contains several FORTRAN source files, needed to read SPICAM or SPICAV FITS data file:

- *spica_read_1a_mod.f*: This module contains the function *spica_read_1a* to read the SPICAM and SPICAV UV/IR data in level 1A. The function returns a FORTRAN derived data type (*struc_1AFile*) corresponding to the FITS file
- *spica_struct_1a_mod_type.f*: This module contains the declarations of the different derived data types specific to the SPICAM/SPICAV UV/IR data level 1A structure
- *spica_struct_1a_mod_func.f*: This module contains the functions used to read all the FITS extension data and header of the SPICAM/SPICAV UV/IR data level 1A
- *test_uv.f*: program to test the *spica_read_1a_mod* module for UV data
- *test_ir.f*: program to test the *spica_read_1a_mod* module for IR data

To build a executable test program, the user should follows these steps:

(Example for gfortran compiler)

- From the root directory the following commands, compile each source file and the main test program:

```
gfortran -ffree-form -c -o "spica_read_1a_mod.o" "spica_read_1a_mod.f"
gfortran -ffree-form -c -o "spica_struct_1a_mod_type.o" "spica_struct_1a_mod_type.f"
gfortran -ffree-form -c -o "spica_struct_1a_mod_func.o" "spica_struct_1a_mod_func.f"
gfortran -ffree-form -c -o "test_uv.o" "test_uv.f"
gfortran -ffree-form -c -o "test_ir.o" "test_ir.f"
```

- link each compiled file with the *cfitsio* library ***libcfitsio.a*** (example for *test_uv*):

```
gfortran -o "test_uv" "spica_read_1a_mod.o" "spica_struct_1a_mod_type.o"
"spica_struct_1a_mod_func.o" "spica_struct_1a_mod_func.o" "test_uv.o" -lcfitsio
```

1.10.3 Returned Structure

The function `spica_read_1a` from the module `spica_read_1a_mod.f` return a specific FORTRAN derived type:

<i>VARIABLE</i>	<i>TYPE</i>
CLEANDATA	REAL ARRAY [NAXIS1, NAXIS2, NAXIS3]
FLAG	REAL ARRAY [NAXIS1, NAXIS2, NAXIS3]
ERRDATA	REAL ARRAY [NAXIS1, NAXIS2, NAXIS3]
INFO	TYPE STRUCT <code>_INFO</code>
PARAMETERS	TYPE STRUCT <code>_PARAMETERS</code>
GEOINFO	TYPE STRUCT <code>_GEOINFO</code>
GEO	TYPE STRUCT <code>_GEO</code>

1.11 C

1.11.1 Installation and execution

Before using the C reading software, the user should build its own *cfitsio* library by following the 4.2.1 section.

The C software package is located in the directories:

```
/net/nfs/spicam/data/ARCHIVE/SOFTWARE/1A/C/
/net/nfs/spicav/data/ARCHIVE/SOFTWARE/1A/C/
```

The package contains several C source and header files, needed to read SPICAM or SPICAV FITS data file:

- `include/spica_read_1a.h`: This header contains the declarations of the main functions used to read the data
- `include/spica_struct_1a.h`: This header contains the declarations of the different typedef specific to the SPICAM/SPICAV UV/IR data level 1A structure
- `include/spica_read_1a_cmd.h`: This header contains the declarations of the functions used to read the data in command line
- `src/spica_read_1a.c`: This source file contains the function which reads the SPICAM and SPICAV UV/IR data in level 1A. The function returns the C typedef (`spica_1Afile`) corresponding to the FITS file
- `src/spica_struct_1a.c`: This source file contains the functions used to read all the FITS extension data and header of the SPICAM/SPICAV UV/IR data level 1A
- `src/spica_read_1a_cmd.c`: This source file contains the functions to reads the data in command line files, and permits to display some data sample, parameters and information

As an example of using the `spica_read_1a` library, the user can build the `spica_read_1a_cmd` program to read the SPICAM/SPICAV 1A data in command line (provided as an example for testing the reading process). To build the project on UNIX system, the user should type first the command `./configure` in the console and then the command `make`. Those 2 commands create the executable file in the “*src*” directory.

1.11.2 Returned Structure

The function `spica_read_1a` from the source file `spica_read_1a.c` return a specific C typedef:

<i>VARIABLE</i>	<i>TYPE</i>
CLEANDATA	FLOAT * ([NAXIS1, NAXIS2, NAXIS3])
FLAG	FLOAT * ([NAXIS1, NAXIS2, NAXIS3])
ERRDATA	FLOAT * ([NAXIS1, NAXIS2, NAXIS3])
INFO	TYPEDEF INFO
FUNCTIONAL_PARAMETERS	TYPEDEF PARAMETERS
GEOINFO	TYPEDEF GEOINFO
GEO	TYPEDEF GEO