Cosmic Optical Background Observations

LORRI_COB external review report

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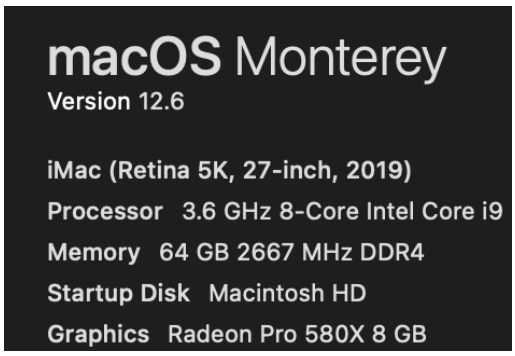
Data overview:

- The LORRI dataset used for measure COB(Cosmic Optical Background)
- PDS version: PDS4
- 1 calibrated dataset
- Total images: 1012
- Time range: 2007-10-05 - 2019-09-04

Review summary:

No major issues found, all images can be open and manipulated. I do have a few questions and suggestions about this data set.

Review environment and tools:



Tools:

- Python Jupyter notebook 6.0.3
- PDS4_Tools v1.3
- Oxygen XML Editor 23.1
- Adobe Acrobat Reader DC 2019

Method:

Following the “Instruction for reviewers”, I checked all the data (image, label, info and values), and read through the documents. I also checked the XML labels with an XML editor.

Report:

- Target in the collection.xml what are they to this dataset? Since this data collection should be “no obvious point sources”.

collection.xml

Target_Identification (12 rows)	name	type	Internal_Reference		
1	(5000) Quaoar	Trans-Neptunian Object	Internal_Reference		
2	(307261) 2002 MS4	Trans-Neptunian Object	Internal_Reference		
3	(10199) Chariklo	Centaur	Internal_Reference		
4	2011 HJ103	Trans-Neptunian Object			
5	(556416) 2014 OE394	Trans-Neptunian Object			
6	INTERPLANETARY DUST	Dust	Internal_Reference	lid_reference	urn:nasa:pds:context:target:dust.dust
				reference_type	data_to_target
7	2018 MF13	Trans-Neptunian Object			
8	(136108) Haumea	Trans-Neptunian Object	Internal_Reference	lid_reference	urn:nasa:pds:context:target:dwarf_planet.136108_haumea
				reference_type	data_to_target
9	NEPTUNE BARYCENTER	Planet	Internal_Reference	lid_reference	urn:nasa:pds:context:target:planet.neptune
				reference_type	data_to_target
10	(28978) Ixion	Trans-Neptunian Object	Internal_Reference	lid_reference	urn:nasa:pds:context:target:trans-neptunian_object.28978_ixion
				reference_type	data_to_target
11	2014 OJ394	Trans-Neptunian Object			
12	(15810) Arawn	Trans-Neptunian Object	Internal_Reference	lid_reference	urn:nasa:pds:context:target:trans-neptunian_object.15810

- The XML label of Nature paper .pdf: pub year 2022? Should be 2017

<?xml	version="1.0" encoding="UTF-8"		
<?xml-model	href="https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1F00.sch" schematypens="http://purl.oclc.org/dsdl/schematron"		
Product_D...	@xmlns	http://pds.nasa.gov/pds4/pds/v1	
	@xmlns:xsi	http://www.w3.org/2001/XMLSchema-instance	
	@xsi:schemaLocation	http://pds.nasa.gov/pds4/pds/v1 https://pds.nasa.gov/pds4/pds/v1/PDS4_PDS_1F00.xsd	
	Identification_Area	logical_identifier	urn:nasa:pds:nh_derived:lorri_cob:nature_preprint.pdfa
		version_id	2.0
		title	Measurement of the Cosmic Optical Background using the Long Range Reconnaissance Imager on New Horizons
		information_model_version	1.15.0.0
		product_class	Product_Document
		Citation_Information	author_list: Zemcov, M.; Immel, P.; Nguyen, C.; Cooray, A.; Lisse, C.; Poppe, A.
			publication_year: 2022
			description: The cosmic optical background is an important observable that constrains energy production in stars and more exotic physical processes in the universe, and provides a crucial cosmological benchmark against which to judge theories of structure formation. Measurement of the absolute brightness of this background is complicated by local foregrounds like the Earth’s atmosphere and sunlight reflected from local interplanetary dust, and large discrepancies in the inferred brightness of the optical background have resulted. Observations from probes far from the Earth are not affected by these bright foregrounds. Here we analyze data from the Long Range Reconnaissance Imager (LORRI) instrument on NASA’s New Horizons mission acquired during cruise phase outside the orbit of Jupiter, and find a statistical upper limit on the optical background’s brightness similar to the integrated light from galaxies. We conclude that a carefully performed survey with LORRI could yield uncertainties comparable to those from galaxy counting measurements.
	Document	document_name	Measurement of the Cosmic Optical Background using the Long Range Reconnaissance Imager on New Horizons
		author_list	Zemcov, M.;Immel, P.;Nguyen, C.;Cooray, A.;Lisse, C.;Poppe, A.
		publication_date	2017-04-10

- Why preprint version? If possible archive the formal version. And change the file name to a formal one, without the pdfa in there.
- Naming convention question:
  What is the time stamp in the file name? It is not any of these, start, stop or mid time.

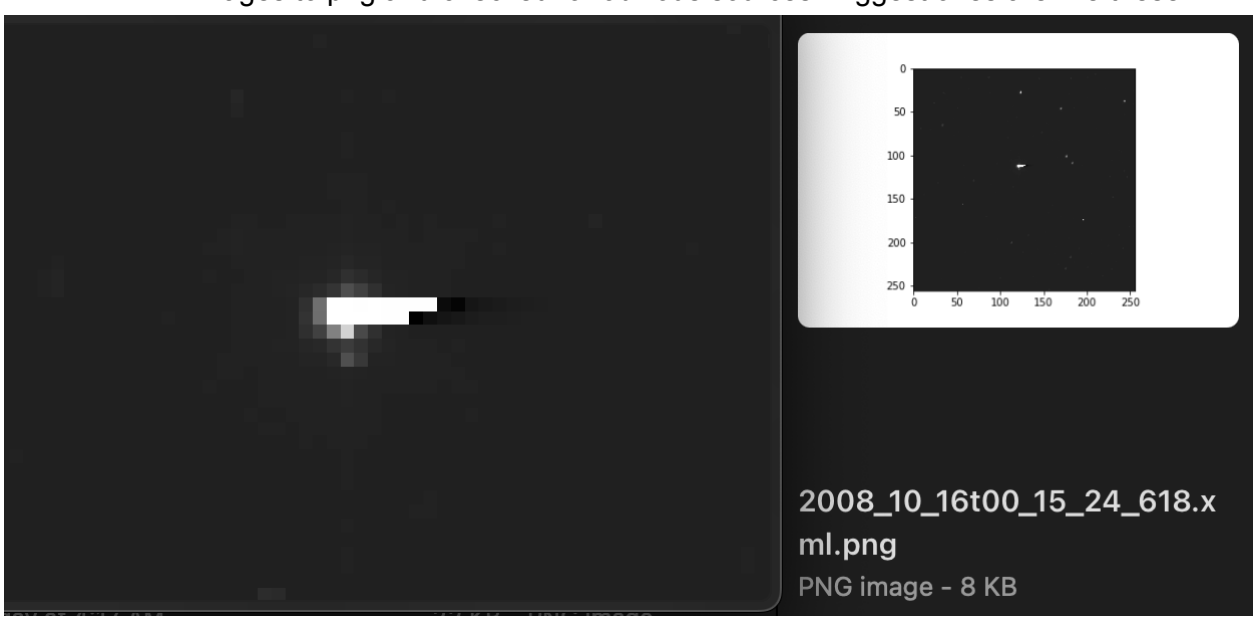
In the XML label description: “The purpose of this observation is to constrain the cosmic optical background (COB).
The file name gives the UTC date and time that the data was taken, in the form YYYY-MM-DDTHH:mm:ss.sss, where T stands for "time."”
Explain the time:

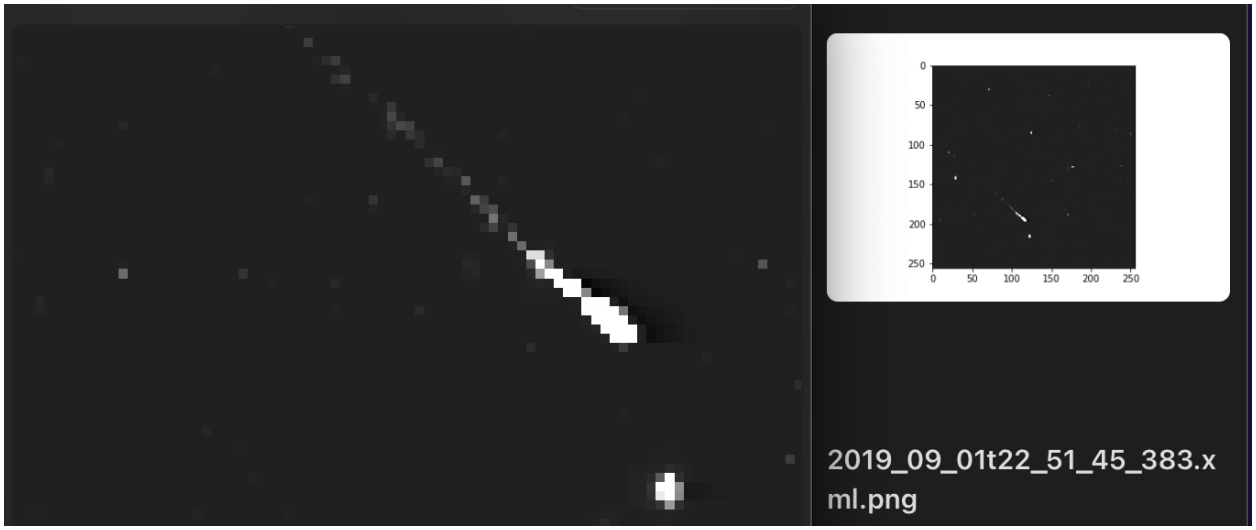
2016_07_13t15_02_15_241.xml*

Product_Observational Observation_Area Observing_System Observing_System_Component

```xml
    </Citation_Information>
  </Identification_Area>
  <Observation_Area>
    <Time_Coordinates>
      <start_date_time>2016-07-13T12:54:40.236Z</start_date_time>
      <stop_date_time>2016-07-13T15:54:18.268Z</stop_date_time>
    </Time_Coordinates>
    <Primary_Result_Summary>
      <purpose>Science</purpose>
      <processing_level>Calibrated</processing_level>
      <Science_Facets>
        <wavelength_range>Visible</wavelength_range>
        <wavelength_range>Near Infrared</wavelength_range>
        <discipline_name>Flux Measurements</discipline_name>
```

- ALL the images can be correctly read by PDS4_tools: read/view
- Image value generally makes sense (-100 < mean < 100). Converted all the images to png and checked for obvious sources. Biggest ones are like these:





- The XML can be ALL validated correctly.
- Data: hard to link to the LORRI data from v6.0 set, but I used a different one to compare the header information.This set is probably generated from another older set other than 6.0.
- Data: the structure looks weird to me, why header is separated as same level as image layer
- Data: no description in XML label for describing the “Image”

```
structures.info()
```

```
0   Header     'HEADER_0'        FITS 3.0
1   Array_2D   'primary_image'   2 axes, 256 x 256
2   Header     'HEADER_1'        FITS 3.0
3   Array_2D   'Image'           2 axes, 256 x 256
```

- Unexplained header rows within the last part of the header_0:

```
CMNT_29 = 'Original key: "END"'
CMNT_30 = ''
CMNT_31 = '--Start of Astrometry.net WCS solution--'
CMNT_32 = '--Put in by the new-wcs program--'
CMNT_33 = ''
WCSAXES =                    2 / no comment
CTYPE1  = 'RA---TAN-SIP'       / TAN (gnomic) projection + SIP distortions
CTYPE2  = 'DEC--TAN-SIP'       / TAN (gnomic) projection + SIP distortions
EQUINOX =                 2000 / Equatorial coordinates definition (yr)
LONPOLE =                  180 / no comment
LATPOLE =                  0.0 / no comment
CRVAL1  =       196.033351346 / RA  of reference point
CRVAL2  =       23.9451954532 / DEC of reference point
CRPIX1  =                  129 / X reference pixel
CRPIX2  =                  129 / Y reference pixel
```

```
CUNIT1  = 'deg     '           / X pixel scale units
CUNIT2  = 'deg     '           / Y pixel scale units
CD1_1   =   -0.000454520192046 / Transformation matrix
CD1_2   =    -0.00104102178412 / no comment
CD2_1   =    -0.00104171376137 / no comment
CD2_2   =    0.000454972319974 / no comment
IMAGEW  =                  256 / Image width,  in pixels.
IMAGEH  =                  256 / Image height, in pixels.
A_ORDER =                    1 / Polynomial order, axis 1
B_ORDER =                    1 / Polynomial order, axis 2
AP_ORDER=                    1 / Inv polynomial order, axis 1
AP_0_1  =                  0.0 / no comment
AP_1_0  =                 -0.0 / no comment
BP_ORDER=                    1 / Inv polynomial order, axis 2
BP_0_1  =                  0.0 / no comment
BP_1_0  =                 -0.0 / no comment
HIST_1  = 'Created by the Astrometry.net suite.'
HIST_2  = 'For more details, see http://astrometry.net .'
HIST_3  = 'Subversion URL'
HIST_4  = 'Subversion revision -1'
HIST_5  = 'Subversion date'
HIST_6  = 'This WCS header was created by the program "blind".'
CMNT_34 = 'Original WCS key: "DATE'"
_ATE    = '2015-12-09T10:26:29' / Date this file was created.
CMNT_35 = '-- blind solver parameters: --'
CMNT_36 = 'Index(0):'
CMNT_37 = '/usr/local/astrometry/data/origin_file/index-4208.fits'
CMNT_38 = 'Index(1):'
CMNT_39 = '/usr/local/astrometry/data/origin_file/index-4207-06.fits'
CMNT_40 = 'Index(2):'
CMNT_41 = '/usr/local/astrometry/data/origin_file/index-4206-06.fits'
CMNT_42 = 'Index(3):'
CMNT_43 = '/usr/local/astrometry/data/origin_file/index-4205-06.fits'
CMNT_44 = 'Index(4):'
CMNT_45 = '/usr/local/astrometry/data/origin_file/index-4204-27.fits'
CMNT_46 = 'Index(5):'
CMNT_47 = '/usr/local/astrometry/data/origin_file/index-4203-27.fits'
CMNT_48 = 'Index(6):'
CMNT_49 = '/usr/local/astrometry/data/origin_file/index-4202-27.fits'
CMNT_50 = 'Index(7):'
CMNT_51 = '/usr/local/astrometry/data/origin_file/index-4201-27.fits'
CMNT_52 = 'Index(8):'
CMNT_53 = '/usr/local/astrometry/data/origin_file/index-4200-27.fits'
CMNT_54 = 'Field name: ../../data/NH/regist//reduc_astro_align.axy'
CMNT_55 = 'Field scale lower: 2.10938 arcsec/pixel'
CMNT_56 = 'Field scale upper: 6.32812 arcsec/pixel'
CMNT_57 = 'X col name: X'
CMNT_58 = 'Y col name: Y'
CMNT_59 = 'Start obj: 30'
CMNT_60 = 'End obj: 40'
CMNT_61 = 'Solved_in: (null)'
CMNT_62 = 'Solved_out: ../../data/NH/regist//reduc_astro_align.solved'
CMNT_63 = 'Solvedserver: (null)'
CMNT_64 = 'Parity: 2'
```

CMNT_65 = 'Codetol: 0.01'
CMNT_66 = 'Verify pixels: 1 pix'
CMNT_67 = 'Maxquads: 0'
CMNT_68 = 'Maxmatches: 0'
CMNT_69 = 'Cpu limit: 600.000000 s'
CMNT_70 = 'Time limit: 0 s'
CMNT_71 = 'Total time limit: 0 s'
CMNT_72 = 'Total CPU limit: 0.000000 s'
CMNT_73 = 'Tweak: yes'
CMNT_74 = 'Tweak AB order: 1'
CMNT_75 = 'Tweak ABP order: 1'
CMNT_76 = '-- '
CMNT_77 = '-- properties of the matching quad: --'
CMNT_78 = 'index id: 4205'
CMNT_79 = 'index healpix: 6'
CMNT_80 = 'index hpnside: 1'
CMNT_81 = 'log odds: 63.1076'
CMNT_82 = 'odds: 2.55429e+27'
CMNT_83 = 'quadno: 551496'
CMNT_84 = 'stars: 363376,363421,363386,363408'
CMNT_85 = 'field: 7,28,9,33'
CMNT_86 = 'code error: 0.00135021'
CMNT_87 = 'nmatch: 24'
CMNT_88 = 'nconflict: 0'
CMNT_89 = 'nfield: 170'
CMNT_90 = 'nindex: 24'
CMNT_91 = 'scale: 4.09078 arcsec/pix'
CMNT_92 = 'parity: 0'
CMNT_93 = 'quads tried: 9593'
CMNT_94 = 'quads matched: 2155'
CMNT_95 = 'quads verified: 0'
CMNT_96 = 'objs tried: 34'
CMNT_97 = 'cpu time: 0.043881'
CMNT_98 = '-- '
CMNT_99 = ''
CMNT_100= '--End of Astrometry.net WCS--'
CMNT_101= '--(Put in by the new-wcs program)--'
CMNT_102= ''
SPCK0074= 'N/A '
SPCK0075= 'N/A '
SPCK0076= 'N/A '
SPCK0077= 'N/A '
SPCK0078= 'N/A '
SPCK0079= 'N/A '
SPCK0080= 'N/A '
SPCK0081= 'N/A '
SPCK0082= 'N/A '
SPCK0083= 'N/A '
SPCK0084= 'N/A '
SPCK0085= 'N/A '
SPCK0086= 'N/A '
SPCK0087= 'N/A '
SPCK0088= 'N/A '
SPCK0089= 'N/A '

```
SPCK0090= 'N/A     '
SPCK0091= 'N/A     '
SPCK0092= 'N/A     '
SPCK0093= 'N/A     '
SPCK0094= 'N/A     '
SPCK0095= 'N/A     '
SPCK0096= 'N/A     '
SPCK0097= 'N/A     '
SPCK0098= 'N/A     '
SPCK0099= 'N/A     '
SPCK0100= 'N/A     '
SPCK0101= 'N/A     '
WINX_000= 'N/A     '
WINY_000= 'N/A     '
WINW_000= 'N/A     '
WINH_000= 'N/A     '
APID_000= 'N/A     '
GRT__000= 'N/A     '
ARCH_000= 'N/A     '
LOADID  = 'N/A     '
REQREC  = 'N/A     '
OPNAV   = 'N/A     '
MSNPHASE= 'N/A     '
MSNSUBPH= 'N/A     '
SCIGRP  = 'N/A     '
SAPID   = 'N/A     '
SAPNAME = 'N/A     '
SAPDESC = 'N/A     '
VISITID = 'N/A     '
VISITNAM= 'N/A     '
VISITDSC= 'N/A     '
RIDEALNG= 'N/A     '
TRGFOVN = 'N/A     '
THRUSTX = 'N/A     '
THRUSTY = 'N/A     '
THRUSTZ = 'N/A     '
SCANRATE= 'N/A     '
RCMODE  = 'N/A     '
PNTMTHD = 'N/A     '
SCSPIN  = 'N/A     '
SPCK0054= 'N/A     '
SPCK0055= 'N/A     '
SPCK0056= 'N/A     '
SPCK0057= 'N/A     '
SPCK0058= 'N/A     '
SPCK0059= 'N/A     '
SPCK0060= 'N/A     '
SPCK0061= 'N/A     '
SPCK0062= 'N/A     '
SPCK0063= 'N/A     '
SPCK0064= 'N/A     '
SPCK0065= 'N/A     '
SPCK0066= 'N/A     '
SPCK0067= 'N/A     '
```

```
SPCK0068= 'N/A     '
SPCK0069= 'N/A     '
SPCK0070= 'N/A     '
SPCK0071= 'N/A     '
SPCK0072= 'N/A     '
SPCK0073= 'N/A     '
__ORDER = 'N/A     '
__3_0   = 'N/A     '
__2_1   = 'N/A     '
__1_2   = 'N/A     '
__0_3   = 'N/A     '
__2_0   = 'N/A     '
__1_1   = 'N/A     '
__0_2   = 'N/A     '
_P_ORDER= 'N/A     '
_P_3_0  = 'N/A     '
_P_1_2  = 'N/A     '
_P_2_0  = 'N/A     '
_P_1_1  = 'N/A     '
_P_2_1  = 'N/A     '
_P_0_3  = 'N/A     '
_P_0_2  = 'N/A     '
FILLCORR= 'N/A     '
MASKCORR= 'N/A     '
BIASMTHD= 'N/A     '
BIASLEVL= 'N/A     '
RDNOISE = 'N/A     '
CCDGAIN = 'N/A     '
A_0_0   = 'N/A     '
A_0_1   = 'N/A     '
A_1_0   = 'N/A     '
B_0_0   = 'N/A     '
B_0_1   = 'N/A     '
B_1_0   = 'N/A     '
AP_0_0  = 'N/A     '
BP_0_0  = 'N/A     '
CMNT_103= 'N/A     '
CMNT_104= 'N/A     '
CMNT_105= 'N/A     '
CMNT_106= 'N/A     '
CMNT_107= 'N/A     '
CMNT_108= 'N/A     '
CMNT_109= 'N/A     '
CMNT_110= 'N/A     '
CMNT_111= 'N/A     '
CMNT_112= 'N/A     '
CMNT_113= 'N/A     '
CMNT_114= 'N/A     '
CMNT_115= 'N/A     '
CMNT_116= 'N/A     '
CMNT_117= 'N/A     '
CMNT_118= 'N/A     '
CMNT_119= 'N/A     '
CMNT_120= 'N/A     '
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```
CMNT_121= 'N/A     '
CMNT_122= 'N/A     '
CMNT_123= 'N/A     '
CMNT_124= 'N/A     '
CMNT_125= 'N/A     '
CMNT_126= 'N/A     '
CMNT_127= 'N/A     '
CMNT_128= 'N/A     '
CMNT_129= 'N/A     '
CMNT_130= 'N/A     '
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CMNT_155= 'N/A     '
CMNT_156= 'N/A     '
CMNT_157= 'N/A     '
CMNT_158= 'N/A     '
CMNT_159= 'N/A     '
CMNT_160= 'N/A     '
TRGFOV00= 'N/A     '           / N/A
SPCK0102= 'N/A     '           / N/A
END
```