$\textbf{KMOS}^{3D}$

RELEASE GUIDE

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July, 2019

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I. Overview

KMOS^{3D} is a Survey of 740 galaxies with redshift, $0.7 < z < 2.7$, observed in the near infrared using the KMOS instrument of the European Southern Observatory Very Large Telescope (VLT). The K-band multi-object spectrograph (KMOS) is a seeing-limited near-infrared integral field spectroscopy system with 24 configurable arms providing a $2.8'' \times 2.8''$ field of view with the spatial sampling of $0.2[\frac{''}{pix}] \times 0.2[\frac{''}{pix}]$.

The aim of the document is to provide information on the released KMOS^{3D} data sets. The following section will introduce the released data, including the naming and structure of FITS files. Further information can be found in Wiskonski et al. 2019.

I.1 File Description

In this data release, FITS files of 740 galaxies observed in the KMOS^{3D} survey are made available on-line. These observations span over two orders of magnitude in galaxy mass, five billion years of cosmic time, and four orders of magnitude of star formation. KMOS^{3D} provides an unparalleled population-wide census of spatially-resolved kinematics, star formation, outflows, and nebular gas conditions. The science cubes contain four extensions:

1. EXT1 contains the calibrated flux cube of the full combined reduced data of the targeted galaxy.
2. EXT2 contains the noise cube for the full combined reduced data. The noise cube presents the standard deviation of the input frames, i.e. individual exposures, at each spaxel in x, y, and λ.

3. EXT3 contains the map of number of individual exposures contributing to each spatial pixel.
4. EXT4 contains the 2D image of the point spread function (PSF), obtained from the stars exposures.

The flux and noise extensions are produced by the SPARK software package (Davies et al. 2013), the official pipeline for Astronomical Reduction with KMOS, with modification from custom routines described in Wiskonski et al. 2019.

I.2 NAMING CONVENTION

The reduced data products are named as **[field]_[targetID]_[band].fits**. In this naming convention [field] is the extragalactic deep field identifier where COS4, GS4, U4 correspond to the COSMOS, GOODS-S, and UDS fields, [targetID] is the unique numerical identifier of the galaxy originating from the 3D-HST V4.1.5 catalog (Skelton et al. 2014; Momcheva et al. 2016). Finally, the [band] corresponds to the observed KMOS YJ-, H-, or K-band.

The primary header contains standard header keywords including exposure time, observing band, and data type info in each extension. The OBJECT is the name of the target galaxy and OBJ_TARG is the object name used at the time it was observed.

II. Release Products

II.1 Data Cubes

II.1.1 Spectral Resolution

The spectral resolution of KMOS ($R \sim 3000-4000$) varies for the 24 different IFUs. In each individual IFU it also varies in the wavelength direction. We derive the resolution as a function of wavelength for each combined cube using Gaussian fits to arc and sky-line measurements in the same IFUs as the science object. The average of the arc measurements is then used to derive a 3rd or 4th order polynomial curve describing the resolution in the individual object cube as a function of wavelength. More details for this procedure are described in Sections 4 and 8 of the KMOS^{3D} data release paper (Wiskonski et al. 2019). Polynomial coefficients of the polynomial (p_0, p_1, p_2, p_3, and p_4) are written to the primary fits header: HIERARCH ESO K3D RESP1, HIERARCH ESO K3D RESP2, HIERARCH ESO K3D RESP3, HIERARCH ESO K3D RESP4.

The resolution (R) in an individual object can be recovered as a function of wavelength (λ_0 in microns):

$$R = p_0 + p_1\lambda_0 + p_2\lambda_0^2 + p_3\lambda_0^3 + p_4\lambda_0^4. \tag{II.1}$$

The polynomial solutions are valid within a certain range of spectral resolution, derived separately in each band, excluding data within 200 angstroms of the ends of the wavelength range. Outside this range, which is given by the primary header keywords "K3D RES MIN" and "K3D RES MAX", polynomials may not accurately recover the resolution curve.

The related header keywords are:

Keywords	Description
HIERARCH ESO K3D RESORDER	Order of polynomial for the instr. resolution
HIERARCH ESO K3D RESIFU	ID of IFUs combined to derive the instr. resolution
HIERARCH ESO K3D RES MIN	Min. spectral resolution
HIERARCH ESO K3D RES MIN	Max. spectral resolution

II.1.2 Spatial Resolution & Fluxes

II.1.2.1 Flux Calibration

The same stars which are observed for telluric correction, are used for flux calibration. Flux calibration is based on the available 2MASS photometry of the standard star. Using the magnitude of the star (mag), the zeropoint (ZP) is defined as

$$mag = ZP - 2.5 \times \log(counts/second). \tag{II.2}$$

The unit of flux in the final calibrated science cubes is $10^{-17}[W/m^2/\mu m]$.

II.1.2.2 PSF Image

A PSF image unique to each galaxy data cube is generated for each galaxy using dithered star observations from the same detector (where possible) and in the same exposures as the corresponding galaxy. These images have been centered and binned in a spatial grid of 21×21 pixels and then stacked. The final fluxes are relative to one and saved in the EXT4 of each date cube. The PSF image gives a measurement of the PSF that is consistent with the total time and conditions corresponding to the science data.

In the fits header of the 4th extension fit parameters for a 2D Moffat and Gaussian models are provided. The value of the FWHM minor axis is assigned as the estimate of the FWHM for the PSF image and the object. The related header keywords are:

Keywords	Description
The PSF best fit moffat parameters	
HIERARCH ESO K3D PSF MOFFAT INTFLUX	moffat: integrated flux in PSF model
HIERARCH ESO K3D PSF MOFFAT FRACFLUX	moffat: fractional flux in image (losses due to IFU size)
HIERARCH ESO K3D PSF MOFFAT AMPL	moffat: amplitude of moffat
HIERARCH ESO K3D PSF MOFFAT BETA	moffat: beta parameter of moff
HIERARCH ESO K3D PSF MOFFAT FWHM_MIN	moffat: FWHM minor axis
HIERARCH ESO K3D PSF MOFFAT FWHM_MAJ	moffat: FWHM major axis
HIERARCH ESO K3D PSF MOFFAT AXRAT	moffat: axis ratio
HIERARCH ESO K3D PSF MOFFAT PA	moffat: position angle
HIERARCH ESO K3D PSF MOFFAT TOTABSRES	moffat: total fit residual
HIERARCH ESO K3D PSF MOFFAT CHISQ	moffat: chi-square of the best fit
The PSF best fit gauss parameters	
HIERARCH ESO K3D PSF GAUSS INTFLUX	gauss: integrated flux in PSF model
HIERARCH ESO K3D PSF GAUSS FRACFLUX	gauss: fractional flux in image (losses due to IFU size)
HIERARCH ESO K3D PSF GAUSS AMPL	gauss: amplitude of gauss
HIERARCH ESO K3D PSF GAUSS FWHM_MIN	gauss: FWHM minor axis
HIERARCH ESO K3D PSF GAUSS FWHM_MAJ	gauss: FWHM major axis
HIERARCH ESO K3D PSF GAUSS AXRAT	gauss: axis ratio
HIERARCH ESO K3D PSF GAUSS PA	gauss: position angle
HIERARCH ESO K3D PSF GAUSS TOTABSRES	gauss: total fit residual
HIERARCH ESO K3D PSF GAUSS CHISQ	gauss: chi-square of the best fit

FWHM estimates derived from a Gaussian model are typically larger than the FWHM derived from a Moffat model as expected from the shapes of their profiles. In general, the Moffat model provides a better fit to the stellar profile.

Model independent PSF characteristics are derived using the background level and peak flux of the star to determine the FWHM. These values are given as the following header keywords to the EXT4 (PSF extentsion):

Keywords	Description
HIERARCH ESO K3D PSF CONST	Data background level
HIERARCH ESO K3D PSF AMPL	Data peak flux
HIERARCH ESO K3D PSF FWHM_MIN	Data minor axis FWHM
HIERARCH ESO K3D PSF FWHM_MAX	Data major axis FWHM

II.2 BOOTSTRAP CUBES

We generate 100 bootstrap realizations of each full combined data cube by selecting random exposures to combine with replacement. These bootstrap cubes randomly sample most sources of systematic and random noise, and can be used for independent error estimation. By propagating the bootstrap cubes through the full analysis, one can assess confidence and errors in derived properties. Due to the large size of each bootstrap cube, we recommend the users to only download these cubes individually for galaxies of interest. The set of bootstrap cubes can be individually downloaded with the following wget command:

```
wget https://www.mpe.mpg.de/resources/KMOS3D/bs/
{field}_{id}_{band}_bootstrap.fits.gz
```

where [field] is the extragalactic deep field identifier. The field identifier is either COS4, GS4, or U4 corresponding to the COSMOS, GOODS-S, and UDS fields. The [id] is the unique numerical identifier of the galaxy originating from the 3D-HST V4.1.5 catalog (Skelton et al. 2014; Momcheva et al. 2016). Finally, the [band] corresponds to the observed KMOS YJ-, H-, or K-band. Each file contains the 100 bootstrapped combinations stored in FITS extensions. For example, to download the the set of bootstrap cubes for the galaxy in GOODS-S field and with the target ID of 02503 in 3D-HST catalog, which is observed in H-band you can use the following command:

```
wget https://www.mpe.mpg.de/resources/KMOS3D/bs/GS4_02503_H_bootstrap.fits.gz
```

II.3 GALAXY CATALOG

We publish a catalog of relevant physical parameters for each target, including magnitudes, star formation rate, dust attenuation, etc. This information is given as a table in a fits format. Below, the presented parameters in the released table are explained.

- ID : KMOS^{3D} Unique identifier
- FIELD : Unique identifier for GOODS-South [GS], COSMOS [COS] or the UDS [U] deep fields
- ID_SKELTON : Numeric ID associated with 3D-HST data release (Skelton et al. 2014)
- ID_TARGETED : KMOS^{3D} original targeting id
- FILE : Associated fits file
- FLAG_PRIMARYTARG : [0] serendipitous galaxy detection within IFU of a primary target, [1] targeted as a primary KMOS^{3D} target
- FLAG_ADDGALDET : [0] no additional galaxy detected [1] additional galaxy detected in the IFU of the primary target
- FLAG_SEGMENTATION : [0] 3D-HST segmentation map[1] is suitable [1] possible issues with photometry and derived parameters resulting from over or under segmentation
- FLAG_ZQUALITY : [0] redshift is secure [1] redshift/detection is uncertain
- RA : Right ascension
- DEC : Declination
- SPEC_RES : Estimated spectral resolution from arc and OH sky lines as described in Wisnioski et al. 2019

[1] The segmentation map indicates which pixels contain flux from objects and has non-zero values where objects are detected.

- Z_TARGETED : Best known redshift from 3D-HST catalog at time of target selection

- OBSBAND : Observed KMOS band

- EXPTIME : Exposure time in minutes

- PSF_FWHM : FWHM of PSF derived from minor axis of MOFFAT model [arcsec]

- Z : Measured redshift from KMOS^{3D} observations, -9999. if not detected

- M_KS : Apparent Ks magnitude (AB) from 3D-HST catalog (Skelton et al. 2014; Momcheva et al. 2016)

- RF_U : Rest frame absolute U-band magnitude (AB) (Skelton et al. 2014)

- RF_V : Rest frame absolute V-band magnitude (AB) (Skelton et al. 2014)

- RF_J : Rest frame absolute J-band magnitude (AB) (Brammer et al. 2012)

- SFR : SFR in $M_{\odot}/yr$ derived from the observed photometry following the ladder of SFR indicators (see Wuyts et al. 2011a,b - Section 2.2.3) (Chabrier IMF)

- SFR_TYPE : [1]=SFR from optical near-IR SED modeling; [2]=SFR from 24μm (pitzer/MIPS); [3]=SFR from 70μm (Herschel/PACS); [4]=SFR from 100μm (Herschel/PACS); [5]=SFR from 160μm (Herschel/PACS)

- LMSTAR : Stellar mass ($M_{\odot}$) from SED modeling following the procedures described by Wuyts et al. 2011a,b (further information can be found in Wiskonski et al. 2019).

- SED_AV : Dust attenuation towards V-band derived from SED modeling

- RHALF : CANDELS H-band major axis effective radius in arcsec

- RHALFERR : error on CANDELS H-band major axis effective radius in arcsec

- Q : CANDELS H-band axis ratio

- QERR : error on CANDELS H-band axis ratio

- FLAG_HSOURCE : The four parameters, Rhalf, Rhalferr, Q, Qerr are derived from HST imaging data set. This flag indicates if these parameter are derived from [1] H-band fit from van der Wel et al. 2012 or [2] H-band fit from Lang et al. 2014

III. References

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