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Catalog of quasars from the Kilo-Degree Survey Data Release 3.

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Keywords: catalogues - surveys - quasars: general -  
large-scale structure of Universe - methods: data analysis -  
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Abstract:

We present a catalog of quasars selected from broad-band photometric ugrI data of the Kilo-Degree Survey Data Release 3 (KiDS DR3). The QSOs are identified by the random forest (RF) supervised machine learning model, trained on Sloan Digital Sky Survey (SDSS) DR14 spectroscopic data. We first cleaned the input KiDS data of entries with excessively noisy, missing or otherwise problematic measurements. Applying a feature importance analysis, we then tune the algorithm and identify in the KiDS multiband catalog the 17 most useful features for the classification, namely magnitudes, colors, magnitude ratios, and the stellarity index. We used the t-SNE algorithm to map the multidimensional photometric data onto 2D planes and compare the coverage of the training and inference sets. We limited the inference set to  $r < 22$  to avoid extrapolation beyond the feature space covered by training, as the SDSS spectroscopic sample is considerably shallower than KiDS. This gives 3.4 million objects in the final inference sample, from which the random forest identified 190,000

quasar candidates. Accuracy of 97% (percentage of correctly classified objects), purity of 91% (percentage of true quasars within the objects classified as such), and completeness of 87% (detection ratio of all true quasars), as derived from a test set extracted from SDSS and not used in the training, are confirmed by comparison with external spectroscopic and photometric QSO catalogs overlapping with the KiDS footprint. The robustness of our results is strengthened by number counts of the quasar candidates in the r band, as well as by their mid-infrared colors available from the Wide-field Infrared Survey Explorer (WISE). An analysis of parallaxes and proper motions of our QSO candidates found also in Gaia DR2 suggests that a probability cut of  $p_{\text{QSO}} > 0.8$  is optimal for purity, whereas  $p_{\text{QSO}} > 0.7$  is preferable for better completeness. Our study presents the first comprehensive quasar selection from deep high-quality KiDS data and will serve as the basis for versatile studies of the QSO population detected by this survey. We publicly release the resulting catalog at <http://kids.strw.leidenuniv.nl/DR3/quasarcatalog.php>, and the code at <https://github.com/snakoneczny/kids-quasars>

#### Description:

The released catalog includes all the KiDS DR3 objects which were subject to the classification (the inference set). Apart from basic columns taken from KiDS DR3 (IDs and coordinates), we add the resulting probabilities for each class in QSO, STAR and GALAXY columns. The final classification, given by the class with the highest probability, is provided in the CLASS column. To obtain the full catalog of all the 190k quasars candidates, one has to query `CLASS == "QSO"`, while the high purity catalog is accessible by taking  $QSO > 0.8$  (see the paper for more details on quality cuts).

#### File Summary:

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FileName	Lrecl	Records	Explanations
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ReadMe	80	.	This file
kids3qso.dat	81	3392580	Objects from KiDS DR3 limited at $R < 22$ , with 3-class (QSO-STAR-GALAXY) photometric classification results
kids3qso.fits	2880	69505	fits version of the catalog

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See also:

II/347 : KiDS-ESO-DR3 multi-band source catalog (de Jong+, 2017)

VII/279 : SDSS quasar catalog: twelfth data release (Paris+, 2017)

Byte-by-byte Description of file: kids3qso.dat

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Bytes	Format	Units	Label	Explanations
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1- 25	A25	---	ID	Source identifier (KiDS JHHMMSS.ss+DDMMSS.ss)
27- 36	F10.6	deg	RAdeg	Right ascension (J2000.0)
38- 47	F10.6	deg	DEdeg	Declination (J2000.0)
49- 54	A6	---	Class	Source classification (GALAXY - QSO - STAR)
56- 63	F8.6	---	Pgal	Source probability of being a galaxy
65- 72	F8.6	---	PQSO	Source probability of being a quasar
74- 81	F8.6	---	Pstar	Source probability of being a star

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(End) Szymon Nakoneczny [NCBJ, Poland], Patricia Vannier [CDS] 23-Feb-2019