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INITIAL DATA RELEASE OF THE KEPLER-INT SURVEY†

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ABSTRACT

This paper describes the first data release of the Kepler-INT Survey (KIS), that covers a 116 deg² region of the Cygnus and Lyra constellations. The Kepler field is the target of the most intensive search for transiting planets to date. Despite the fact that the Kepler mission provides superior time series photometry, with an enormous impact on all areas of stellar variability, its field lacks optical photometry complete to the confusion limit of the Kepler instrument necessary for selecting various classes of targets. For this reason, we follow the observing strategy and data reduction method used in the IPHAS and UVEX galactic plane surveys in order to produce a deep optical survey of the Kepler field. This initial release concerns data taken between May and August 2011, using the Isaac Newton Telescope on the island of La Palma. Four broadband filters were used, U, g, r, i, as well as one narrowband one, Hα, reaching down to a limit of ~ 20th mag in the Vega system. Observations covering ~ 50 deg² passed our quality control thresholds and constitute this first data release. We derive a global photometric calibration by placing the KIS magnitudes as close as possible to the Kepler Input Catalog (KIC) ones. The initial data release catalogue containing around 6 million sources from all the good photometric fields is available for download from the KIS webpage†. 

Subject headings: surveys - stars: general, emission-line - catalogues - techniques: photometric

1. INTRODUCTION

We present an initial data release of the Kepler-INT Survey (KIS). This paper describes optical observations carried out on the Isaac Newton Telescope (INT), covering about one half of the Kepler field down to ~ 20th magnitude. A short description of the Kepler mission and the INT is given in this Section of the paper. Section 2 describes the INT observations and data products, while Section 3 explains the photometric calibration of the data using the Kepler Input Catalog (KIC, Brown et al. 2011). In Section 4, we discuss our results and provide a description of the catalogue in Section 5.

1.1. Kepler mission

The Kepler mission’s (Borucki et al. 2010) main goal is to discover Earth-size planets within the habitable zones of Sun-like stars. NASA’s Kepler spacecraft, which was launched in March 2009, contains a differential broadband optical (4,200 - 9,000Å) CCD array with a wide field of view (FoV) of 116 deg², mounted on a modified 0.95m Schmidt telescope continuously observing a region in the Cygnus and Lyra constellations. Due to the onboard storage and telemetry bandwidth limitation, only 170,000 sources, out of the millions present within the FoV, can be observed and downloaded to Earth at any given time. Therefore, the targets must be pre-selected prior to the observations.

Kepler provides uninterrupted time series photometry that is superior to any previous ground-based study. Although Kepler was designed for the detection of exoplanets, its high-quality light curves hold an enormous potential for other astrophysical domains such as asteroseismology (Chaplin et al. 2010), stellar activity (Busby et al. 2011), star spot monitoring (Lima et al. 2012), eclipsing and close binary systems (Prsa et al. 2011; Counsell et al. 2011), gyrochronology (Mercier et al. 2011), accreting white dwarfs (Fontaine et al. 2011; Still et al. 2010; Wood et al. 2011), the study of RR Lyrae stars (Benko et al. 2010; Nemec et al. 2011) as well as systems showing stochastic behaviour in the variability of their fluxes (Mushotzky et al. 2011; Scaringi et al. 2012). Kepler data has also enabled the first deter-
minution of radial velocity amplitudes of binary systems through Doppler boosting (van Kerkwijk et al. 2010).

Kepler operates two types of observation modes: the short (one minute) and long (30 minutes) cadence modes. The Guest Observer (GO) program offers a yearly opportunity for the observation of 5,000 long cadence targets per quarter and 40 short cadence targets per month, through a peer-reviewed competition, which is open for all astrophysical domains. Every 3 months, the Kepler mission also offers the opportunity for a few dozen targets to be observed through Director’s Discretionary Time (DDT) Proposals. Finally, every quarter, the Kepler Asteroseismology Science Consortium (KASC) can bid more than \( \sim 1,700 \) targets in order to study stellar pulsations.

It is therefore clear that the short cadence mode slots are very limited, thus a target must be well studied from the ground in order to justify required time with Kepler. In order to observe candidate planet hosts, mainly G-M type main-sequence stars, the Kepler team created the Stellar Classification Project (SCP), with a main goal to prevent the selection of non-main-sequence stars, by providing important stellar parameters (radius, effective temperature, apparent magnitude, etc) of the sources in the Kepler FoV. A photometric study of the Kepler field, mainly using griz broadband filters was produced and stored in what is known as the Kepler Input Catalog (Brown et al. 2011). Since the main purpose of the KIC was to pre-select solar-like stars, the reliable depth of this survey is \( g \sim 16 \) mag, and there was no need to include a filter bluer than the \( g \)-band. However, it is clear that many fainter objects within the Kepler FoV, which can not be studied using KIC data, are of interest to non-exoplanet science such as cataclysmic variables (Wood et al. 2011), pulsating white dwarfs (Østensen et al. 2011a; Hermes et al. 2011) and active galactic nuclei (Mushotzky et al. 2011).

The GO and KASC programs show that there is a large interest in fainter and bluer objects. In order to pre-select other, rarer types of targets such as hot, young, or active stars, white dwarfs or subdwarfs, and accreting objects, a deeper optical survey of the Kepler field, including a bluer than \( g \) filter, is required. Also, the addition of an \( H_{\alpha} \) filter would be useful to detect emission line objects, mainly accreting ones, as well as strong \( H_{\alpha} \) deficit sources such as hydrogen-rich white dwarfs. Therefore, the INT Photometric \( H_{\alpha} \) Survey of the Northern Galactic Plane (IPHAS, Drew et al. 2005) and the UV-Excess Survey of the Northern Galactic Plane (UVEX, Groot et al. 2009) collaborations made use of their available data reduction pipeline and observation strategy to obtain a homogeneous \( Ugrj \) and \( H_{\alpha} \) catalogue of the Kepler FoV, down to \( 20^{\text{th}} \) mag in all five filters. All magnitudes are given in the Vega system (Morgan et al. 1953). We have named this effort the Kepler-INT Survey (KIS). KIS should be useful not only because it can identify UV-excess objects and \( H_{\alpha} \) emitters, but also because it goes much deeper than KIC. Even though other collaborations are also conducting optical surveys of the Kepler field, such as the UBV Photometric Survey of the Kepler field (Everett et al. 2012), only KIS provides the critical deep \( U \)-band and \( H_{\alpha} \) imaging.

1.2. Survey imaging with the Isaac Newton Telescope

The 2.5m Isaac Newton Telescope (INT) is located in the Roque de los Muchachos Observatory on La Palma. The Wide Field Camera (WFC), mounted in its prime focus, is an optical imager consisting of 4 anti-reflective-coated 2048 \( \times \) 4096 pixel CCDs, arranged in an L-shape. It has a pixel scale of 0.333 arcsec and a field of view of 0.29 deg\(^2\) (González-Solares et al. 2008).

Four broadband filters (\( Ugrj \)) and one narrowband filter (\( H_{\alpha} \)) were used to obtain the INT data. The filter characteristics are provided in Table 1. Unlike \( g \), \( r \) and \( i \) which are SDSS-like filters, the \( U \)-band is a non-standard \( U \) filter and it is affected by the CCD detector response dropping at its blue edge. For more information on the \( U \) filter, see Verbeek et al. (2012).

The wealth of the available IPHAS and UVEX data have been used to develop selection methods to detect objects of special interest such as \( H_{\alpha} \) emitters (Witham et al. 2006), cataclysmic variables (Witham et al. 2007), planetary nebulae (Viironen et al. 2009), symbiotic stars (Corradi et al. 2008), early-A stars (Drew et al. 2008), extremely red stellar objects, including mainly Asymptotic Giant Branch stars, and S-type stars (Wright et al. 2008, 2009), very low-mass accreting stars and brown dwarfs (Valdivielso et al. 2009) and UV-Excess sources (Verbeek et al. 2012). Candidates were primarily selected through the use of colour-colour diagrams. Their findings and selection methods were then confirmed using spectroscopic data. Surveys such as IPHAS and UVEX have enabled the development of automated searches of a large number of unusual and ‘exotic’ objects.

2. INT OBSERVATIONS AND DATA

2.1. Observations

As our data processing recipe is identical to that of the IPHAS and UVEX surveys, we refer to Drew et al. (2005), González-Solares et al. (2008) and Groot et al. (2009) for details. The observing strategy consists of dividing the entire survey region into fields, each of them corresponding to the area of the WFC’s FoV. A five percent overlap is included between adjacent pointings. Also, in order to cover the gaps between the four detectors, comprising \( \sim 12 \) arcmin\(^2\), each field is observed in pairs with an offset of 5 arcmin North and 5 arcmin East between the pointings. This leads to two detections of most objects observed.

In order to balance the survey progress with the calibration quality of the data, approximately five ob-
observations of standards are taken throughout each night. These observations allow us to derive accurate zero-point magnitudes (ZPs) for each broadband filter per night without using too much of the allocated time on the telescope. The zero-point RMS of each night allows one to assess whether a night is considered ‘photometric’ (González-Solares et al. 2008).

### 2.2. Data

The data processing is described in detail in Section 3 of González-Solares et al. (2005). The final data products consist of images and band-merged catalogues with equatorial positions tied to 2MASS (Two Micron All Sky Survey, Skrutskie et al. 2006). Vega magnitudes and errors in all five filters and morphological flags (see Table 2). Further information on each detected object, such as CCD pixel coordinates in each waveband and the CCD in which the source was detected, are also provided in the catalogues. The astrometric precision of the end product is better than 100 mas across all four CCDs (González-Solares et al. 2008).

In the UVEX data reduction pipeline, the $U$-band zero-point magnitudes are tied to the $g$-band ones with a fixed offset of $(ZP_U - ZP_g) = 2.1$ mag, similarly to the case of the Hα ZPs in IPHAS (Drew et al. 2005) which are tied to the $r$-band via a fixed offset of 3.14 mag. The nightly $g$-band zero-points are derived from the standards observed throughout each night. However, in the KIS, we depart from UVEX in the $U$-band by using actual standard star ZPs to obtain $U$-band magnitudes, in the same way as we do for $g, r$ and $i$ (see Section 3 for more details). The Hα zero-points for each nights remain tied to the $r$-band ones, similarly to the way they are calculated in IPHAS (Drew et al. 2005), since there is no Hα standard available.

A bubble in the $U$ filter was discovered that was visibly affecting a corner of the $U$-band images, and a red leak is also known to exist in the filter (Verbeek et al. 2012). The bubble was fixed on the $15^{th}$ of June 2011. However, Calima - dust winds which originate in the Saharan desert - was strongly present during that period of the observations. This affected the pre-June $20^{th}$ $U$-band data in particular.

#### TABLE 2

**Morphological flags**

<table>
<thead>
<tr>
<th>Flags</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9</td>
<td>saturated</td>
</tr>
<tr>
<td>-8</td>
<td>poor match</td>
</tr>
<tr>
<td>-7</td>
<td>contains bad pixels</td>
</tr>
<tr>
<td>-1</td>
<td>stellar</td>
</tr>
<tr>
<td>-2</td>
<td>probably stellar</td>
</tr>
<tr>
<td>-3</td>
<td>compact but probably not stellar</td>
</tr>
<tr>
<td>1</td>
<td>non-stellar (e.g. a galaxy)</td>
</tr>
<tr>
<td>0</td>
<td>no detection</td>
</tr>
</tbody>
</table>

During the 2011 observing season, a total of 742 INT pointings, consisting of fields and offsets, were observed. However, not all of them pass the quality control threshold set for this survey. We only select fields which were observed under ‘clear’ conditions where the RMS on the derived nightly zero-points must be smaller than 0.10 mag. Additional quality control tests related to the observing conditions include selecting pointings which have $r$-band seeing < 2 arcsec and $r$ and $g$-bands sky background values < 2000 ADUs, to remove observations done too close to the moon. The distribution of seeing in the $r$-band, for all 742 pointings, is shown in Figure [1] which clearly indicates that some pointings were indeed observed under non-ideal conditions. Also, we use an additional measurement, the ellipticity, which is a detector-averaged value that flags any tracking and focussing issues of the telescope that were possibly encountered on a given night. We keep fields with mean $r$-band ellipticity values below 0.2 and any larger value would trigger a re-observation.

Given the existence of the well-calibrated KIC catalog, which has served as the principal survey for selecting Kepler targets, we decided to tie our absolute photometric calibration to the KIC broad-band magnitudes. We make use of the KIC to set an additional quality control criterion. We calculate the difference between the KIC magnitudes and the KIS magnitudes for sources with $g$-band magnitudes between 13 and $15^{th}$ mag. These limits were chosen because KIS magnitudes smaller than $\sim12^{th}$ mag become much less reliable and the photometric accuracy of KIC deteriorates below $\sim16^{th}$ mag. More details on this can be found in the following Section. We plot the distribution of the offsets in the $g, r$ and $i$ bands ($\Delta g$, $\Delta r$ and $\Delta i$). The median values of these offsets, corresponding to the centre of their distributions (see Figure 2), are given in Table 3. In addition to the quality tests discussed previously, we select fields which have a median offset in each waveband within $\pm0.2$ mag of the values given in Table 3. This only rejects $\sim5\%$ of our pointings.

Out of all 742 observed fields, 513 pointings are classified as ‘good’, which is equivalent to $\sim70\%$ of the total number of pointings observed so far. In Figure 3 we plot the centres of these ‘good’ INT pointings on the Kepler FoV. We indicate the boundaries of the sky footprints of the CCDs on the Kepler satellite.

### 3. Photometric Calibration

For the KIS catalogue, we start by calibrating $Ugri$ to the standards observed each night by taking the average nightly ZPs in each filter, while the Hα ZP is tied to the nightly $r$-band ZP by a fixed offset. This calibration can introduce ZP errors if the night is not ‘clear’ since all pointings in a given night employ the same ZPs. By placing our ZPs as close to the KIC ones as possible, we can improve our photometric calibration on a pointing by pointing basis rather than only for a full night’s worth of data.
Fig. 1.— $r$-band seeing in arcseconds of all INT pointings. Fields observed under seeing conditions worse than 2 arcsec were not included in the initial data release catalogue.

Fig. 2.— Distribution of $\Delta g$, $\Delta r$ and $\Delta i$, for all pointings, where $\Delta \{\text{filter}\}$ is the offset between the KIC and KIS magnitudes (see Section 3). As one can see, the offsets rarely exceed 5%. There are, however, a few outliers with offsets larger than -0.3 or +0.4 magnitude that fall outside the plotted range.

Fig. 3.— INT coverage of Kepler fields. The red circles correspond to the centre of the INT pointings which were classified as observed during ‘clear’ conditions. The boundaries of the sky footprints of the CCDs on the Kepler satellite are also shown in black.

Kepler FoV, which overlap with SDSS DR1 (Stoughton et al. 2002) and which are used as photometric standards. Spanning a wide range of RA around the Kepler field, 316 primary standard stars were chosen. Each night, standards were taken on an hourly basis in order to calculate the transformations between the KIC and SDSS magnitudes. However, it is important to note that out of the ~13 million detected objects, less than 3 million have reliable g-band magnitudes. The rest are either fainter than 16th mag or are not provided with a magnitude value but only a position.

A specially designed pipeline was used to reduce the image data to catalogues of star positions and apparent magnitudes. The photometric calibrations were done using the time-averaged extinction-corrected magnitudes from the standards stars (Brown et al. 2011). The photometric precision of the KIC sources is expected to be ~1.5%.

Since the KIC was created mainly for selecting solar-type stars brighter than 16th mag, its photometry can only be considered reliable for sources brighter than this limit. KIS however is not reliable for objects brighter than ~12th mag so we only cross-match KIS with KIC objects having g-band magnitudes between 13 and 15th mag. Given that the astrometry of both catalogues are based on well-resolved CCD data, we used a matching radius of 1 arcsec. Additional information on the KIC astrometry can be found on the Kepler webpage*. Since the KIC photometry is based on the AB system (Oke & Gunn 1983) and the INT data is all in the Vega magnitude system, we converted the KIC data to the Vega system using the transformations from Gonzalez-Solares

*http://keplergo.arc.nasa.gov/Documentation.shtml

We cross-matched the INT data with the Kepler Input Catalog (KIC), containing over 13 million detected objects. A full explanation of the catalogue production can be found in Brown et al. (2011), but we provide a brief description of it here. The KIC photometric data was placed as close as possible to the Sloan photometric system (Brown et al. 2011), by selecting 8 fields outside the
We stress that these transformations are reliable for main-sequence stars but are not to be trusted for blue objects which have a small \((U-g)\) colour. In order to verify this, we cross-match the KIS data with Sloan Digital Sky Survey (SDSS, Loveday 2002) and select matches with \(r\)-band magnitudes ranging from 15 to 18 mag. Only \(\sim 25\%\) of the KIS pointings overlap with SDSS and therefore this test is only used to determine the range over which these transformations are valid. The transformations taken from González-Solares et al. (2011) were derived using a more robust algorithm.

In our test, we plot the difference between SDSS and KIS magnitudes in \(U\) against \((u-g)\) colours from SDSS (see Figure 4). We bin the data in colour bins of 0.1 mag and calculate the median of the difference between the SDSS and KIS magnitudes. These values correspond to the red circles. The error bars are the standard deviations of the binned data. As we can see, the transformations provided by González-Solares et al. (2011) are verified in the plots for objects within \(1 < (u-g) < 3\). In both the red and blue ends of the plots, the data points do not follow the linear fit for the main locus of stars.

The KIC contains \(g\), \(r\) and \(i\)-band magnitudes for all sources. For these bands, our photometric corrections are thus simply:

\[
\Delta g = g_{\text{WFC}} - g_{\text{KIC}} \\
\Delta r = r_{\text{WFC}} - r_{\text{KIC}} \\
\Delta i = i_{\text{WFC}} - i_{\text{KIC}}
\]

The distributions of these offsets are shown in Figure 2. As can be seen, the values of these offsets were typically a few percent, rarely exceeding \(5\%\) for fields passing the quality control threshold. These values are provided in the final catalogue of the Kepler-INT Survey.

In order to have a more accurate calibration, we calculated these offsets for each WFC CCD separately. In general, all four CCDs behaved the same way. For each INT Kepler field, we calculate the median of the offsets of all matched sources in each passband for each WFC CCD (for instance, median\((\Delta g_{\text{CCD1}})\), median\((\Delta g_{\text{CCD2}})\), median\((\Delta g_{\text{CCD3}})\), median\((\Delta g_{\text{CCD4}})\), and similarly for \(r\) and \(i\) bands).

As KIC lacks \(u\)-band data, the KIS \(U\)-band can not have an absolute calibration like in the case of \(g\), \(r\) and \(i\). We decided to use the \(g\)-band offset also for \(U\). In summary, to calibrate the INT photometry, we applied the following equations to the sources in each INT pointing and CCD:

\[
U'_{\text{WFC}} = U_{\text{WFC}} - \Delta g_{\text{CCD#}} \\
g'_{\text{WFC}} = g_{\text{WFC}} - \Delta g_{\text{CCD#}} \\
r'_{\text{WFC}} = r_{\text{WFC}} - \Delta r_{\text{CCD#}} \\
i'_{\text{WFC}} = i_{\text{WFC}} - \Delta i_{\text{CCD#}} \\
H'\alpha_{\text{WFC}} = H\alpha_{\text{WFC}} - \Delta r_{\text{CCD#}}
\]

where the prime indicates the calibrated magnitudes.

4. DISCUSSION

The 513 fields that were classified as reliable and observed during ‘clear’ nights are all observed starting from the \(21^{st}\) of June 2011. Colour-colour diagrams helped us assess the state of the data, in order to make sure that the selected pointings do indeed behave as the Pickles and Koester model tracks predict (Drew et al. 2005; Verbeek et al. 2012). In fact, we plotted individual \((U-g, g-r)\) and \((r-i, r-H\alpha)\) colour-colour diagrams of each INT pointing, with Pickles main-sequence tracks as well as DA (hydrogen-rich) white dwarf track from Koester models. All the synthetic colours are available in the Vega system from Drew et al. (2005) for \((r-i, r-H\alpha)\) colours of main-sequence stars, and Groot et al. (2009) for their \((U-g, g-r)\) colours. The DA white dwarfs colours were taken from Verbeek et al. (2012).

5. CATALOGUE DESCRIPTION

With all reliable pointings at hand, we produced the KIS initial release catalogue. We combine all the data from the 513 pointings in a single catalogue containing \(\sim 6\) million sources.

We produce two versions of the catalogue: a standard version and an extended one. A description of the columns of the catalogue is given in Table 3 and an example of a few lines taken from the standard version is shown in Table 4. It contains the positions of the sources in degrees, their magnitudes and errors, as well as their morphological classes in each waveband (see Table 2 for more details). We also give each KIS source an ID, found in the first column of the tables. It simply corresponds to the ‘KISJ’ prefix, followed by the object’s KIS coordinate given in sexagesimal notation. Finally, when a KIS object had a match in the Kepler Input Catalog within 1 arcsec, we added the Kepler ID of that match in the final column of the table. If no match was found, the Kepler ID is equal to 0.
The extended catalogue contains further information on each source, such as the CCD in which it was detected, their CCD pixel coordinates, the seeing, ellipticity and modified Julian date in each filter and the offsets between the KIS magnitudes and KIC magnitudes which were used to calibrate the KIS catalogue. The seeing and ellipticity values given for each source are average values for the given INT pointing in which the object was detected.

Most sources had two detections, therefore the magnitude and errors provided in the catalogue are mean values of the magnitudes and errors, calculated from the magnitudes and errors of detections of the same source found in an INT and its paired field. We also compute the RMS of the magnitudes for each source in order to compare the difference between the magnitudes in both detections, within their error bars. If the value of the calculated RMS is large compared to the errors, it would reflect on short timescale variability or on non-ideal observing conditions. In the case of a single detection, the RMS is set to -1. The overlap between non-paired pointings was not taken into account for the search of duplicates, therefore the final catalogue will still contain two detections of the same source. The reason why we allow for a mean value to be calculated in this case is because the paired fields are observed one after the other, under very similar conditions.

In order to test the potential of the KIS catalogue to identify rare and unusual objects in the Kepler field, we cross-match KIS with known published sources within the Kepler FoV such as the pulsating subdwarfs and white dwarfs from Østensen et al. (2011), Hermes et al. (2011), the cataclysmic variables (CVs) from Williams et al. (2010), Wood et al. (2011), Fontaine et al. (2011) and the active galactic nuclei (AGN) from Mushotzky et al. (2011). The objects which had matches in KIS are plotted in colour space (Figure 7). We also include a recently spectroscopically confirmed ultra-cool dwarf (R. Tata, E. L. Martin & E. Martioli poster presented at the ‘First Kepler Science Conference’) in the (r- Hα, r - i) colour-colour diagram of Figure 7 which did not have a U-band detection. We see that the different types of objects fall within their expected locations in colour-space. The CVs are indeed found in the (U - g, g - r) colour-colour diagram with (U - g) < 0 and they also stand out as Hα emitters in the (r - Hα, r - i) diagram. Also, the DA white dwarfs are known to be Hα deficit objects, which can be seen in the bottom panel of Figure 7.

6. Conclusion

We obtained Ugri and Hα data for part of the Kepler field using the WFC on the INT. The data were processed in the Cambridge Astronomical Survey Unit (CASU) in the same fashion as for IPHAS (Drew et al. 2005) and UVEX (Groot et al. 2009), with the exception of the U-band magnitudes, which in the KIS case were calculated using the mean ZP values from the standard stars observed each night.

The KIS magnitudes were calibrated by shifting our zero-points to match the KIC gri photometry. This way, we improved our photometric calibration on a pointing by pointing basis rather than a full night.

Of the 742 pointings obtained throughout the entire run, 513 of them passed the quality control threshold set for this survey, covering ∼ 50 deg2. Most sources in the KIS have two detections. In such cases, we derive a
Fig. 6.— Distribution of the number of sources as a function of KIS magnitudes. The objects taken into account are the ones classified as ‘stellar’ in all five filters.

The initial data release KIS catalogue contains $\sim 6$ million objects, with $Ugri$ and $H\alpha$ magnitudes, down to $\sim 20^{th}$ magnitude in the Vega system. Out of those $\sim 6$ million sources, $\sim 1.2$ million of them are classified as ‘stellar’ in all five filters. The plan is to observe the remainder of the field in 2012, followed by a second data release containing all data.

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Fig. 7.— Colour-colour diagrams of some of the published pulsators, white dwarfs, CVs, ultra-cool dwarfs and AGNs in the Kepler field. The Pickles tracks are taken from Drew et al. (2005) in the lower panel, and from Groot et al. (2009) in the top panel. The red tracks in the both panels correspond to Koester models of DA WDs with constant surface gravity, log $g = 8$, taken from Verbeek et al. (2012). The scatter points are stellar objects taken from the KIS catalogue.
<table>
<thead>
<tr>
<th>Column name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIS_ID</td>
<td>KIS ID containing the coordinate of the source, in sexagesimal notation.</td>
</tr>
<tr>
<td>RA</td>
<td>Right Ascension (J2000), in degrees.</td>
</tr>
<tr>
<td>Dec</td>
<td>Declination (J2000), in degrees.</td>
</tr>
<tr>
<td>mean_U, mean_g, mean_r, mean_i, mean_Hα</td>
<td>Magnitudes of sources, given in the Vega system. In the case of two detections, the mean value is given.</td>
</tr>
<tr>
<td>U_err, g_err, r_err, i_err, Hα_err</td>
<td>Magnitude errors. In the case of two detections, the mean error is given.</td>
</tr>
<tr>
<td>rms_U*, rms_g*, rms_r*, rms_i*, rms_Hα*</td>
<td>Root-mean-square (rms) of magnitudes of sources with two detections. In the case of a single detection, the rms value is set to -1.</td>
</tr>
<tr>
<td>x_U*, x_g*, x_r*, x_i*, x_Hα*</td>
<td>X pixel coordinate of source.</td>
</tr>
<tr>
<td>y_U*, y_g*, y_r*, y_i*, y_Hα*</td>
<td>Y pixel coordinate of source.</td>
</tr>
<tr>
<td>class_U, class_g, class_r, class_i, class_Hα</td>
<td>Morphological class of source (see Table 2).</td>
</tr>
<tr>
<td>CCD*</td>
<td>WFC’s CCD in which the source was detected.</td>
</tr>
<tr>
<td>seeing_U*, seeing_g*, seeing_r*, seeing_i*, seeing_Hα*</td>
<td>Average seeing of the INT pointing, given in arcsec.</td>
</tr>
<tr>
<td>ellipticity_U*, ellipticity_g*, ellipticity_r*, ellipticity_i*, ellipticity_Hα*</td>
<td>Average ellipticity of the night.</td>
</tr>
<tr>
<td>MJD_U*, MJD_g*, MJD_r*, MJD_i*, MJD_Hα*</td>
<td>Modified julian date of observation.</td>
</tr>
<tr>
<td>delta_U*, delta_g*, delta_r*, delta_i*, delta_Hα*</td>
<td>Difference between KIS and KIC magnitudes applied to calibrate KIS data.</td>
</tr>
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