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Photometric data around us

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Abstract. A researcher of variable stars needs photometric data. Their sources could be very varied, from our own observations to different photometric surveys or previously published papers. In this paper, we present the tool PDR for retrieving photometric data from selected surveys and the system AMPER for archiving photometric data for periodic variable stars.

Key words: photometry – surveys – data

1. Introduction

From the beginning, astronomy is a science based on observational data, their analyses and interpretations. Even though we are flooded with big data nowadays, to obtain time series of selected target(s) in suitable time-resolutions and several photometric bands is often a very difficult and time-consuming task. However, data search is only one part of the task. The competence of the correct processing of the found data is also very important.

Furthermore, one has to be careful reading old texts, because common styles of the given timings, magnitudes, errors, and filters are changing over time. Sometimes the heliocentric correction and the way of its computation and application, are wrong.

The lack of photometric data can be solved by our own observations if possible. We can also ask for assistance from amateur observers, who are often able to provide high quality data. Photometric observations made by amateurs are not appreciated duly even though amateurs, or small observatories, produce huge amount of data. Unfortunately, their data are hidden somewhere or even deleted. CCD cameras have been widely used for several decades. Let's imagine one observer with one telescope and a CCD camera, who has been active for 10 years. Each year he observes for, let say, 50 nights. Each night he obtains 100 frames with 100 stars in them. In total, we obtain 5 millions photometric points with this pessimistic estimate. However, some observers have more telescopes, observe more nights with more frames per night and have more stars in frames. Adjusting our estimate to 10 years, 100 nights/year, 500 frames/night, 10 000 stars/frame, we obtain five billion photometric points! And this is only an estimate for one observer, or a small observatory. In total, all data from this source are comparable with data from a huge survey.

2. Photometric surveys

Very valuable pieces of information are included in historical surveys made on photographic plates. However, only part of them is digitalized and available to the public. Let us mention, as a very nice example, the project DASCH (http://dasch.rc.fas.harvard.edu/).

Nowadays, we can use data from many ground based surveys as for example:

- *ASAS - http://www.astrouw.edu.pl/asas/,
- *OGLE - http://ogle.astrouw.edu.pl/,
- *MACHO - http://wwwmacho.anu.edu.au/Data/MachoData.html,
- EROS - http://eros.in2p3.fr/,
- *ROTSE (NSVS) - http://www.rotse.net/,http://skydot.lanl.gov/nsvs/nsvs.php,
- *SuperWASP - http://wasp.cerit-sc.cz/form,
- *APASS - http://www.aavso.org/apass,
- SDSS - http://www.sdss3.org,
- *Catalina (CRTS) - http://crts.caltech.edu/,
- 2MASS - http://www.ipac.caltech.edu/2mass/,
- *LINEAR - https://astroweb.lanl.gov/lineardb/,
- TASS - http://www.tass-survey.org/,
- Stardial - http://stardial.astro.illinois.edu/,
- HATNet - http://www.hatnet.org/,
- *Pi of the sky - http://grb.fuw.edu.pl/,
- Pan-STARRS ??? http://pan-starrs.ifa.hawaii.edu/,
- *ASAS-SN http://www.astronomy.ohio-state.edu/~assassin/index.shtml,
- MASCARA https://home.strw.leidenuniv.nl/~burggraaff/MASCARA_variables/.
- *PTF - https://www.ptf.caltech.edu/,
- *KWS - http://kws.cetus-net.org/~maehara/VSdata.py

Great collections of data are available from space projects such as

- *Hipparcos - https://www.cosmos.esa.int/web/hipparcos/catalogues,
- *OMC Integral - https://sdc.cab.inta-csic.es/omc/index.jsp,
- MOST - http://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/most/,
- COROT - http://idoc-corot.ias.u-psud.fr/,
- *KEPLER,K2 - http://kepler.nasa.gov, http://keplerscience.arc.nasa.gov,
- Chandra - http://cxc.harvard.edu/vguide/index.php,
- GAIA - http://sci.esa.int/science-e/www/area/index.cfm?fareaid=26,
- BRITE - http://www.brite-constellation.at/,
- WISE - http://wise.ssl.berkeley.edu/,
- TESS - https://tess.gsfc.nasa.gov/.

Data from photometric surveys are usually available on their webpages or mirrors or on specialised data servers such as CDS (Centre de Données astronomiques de Strasbourg) http://cdsportal.u-strasbg.fr/, MAST (Barbara A. Mikulski Archive for Space Telescopes) http://mast.stsci.edu/

portal/Mashup/Clients/Mast/Portal.html, IPAC, IRSA (Infrared Processing and Analysis Center, Infrared Science Archive) http://www.ipac.caltech.edu/, http://irsa.ipac.caltech.edu/frontpage/, Canadian Astronomy Data Centre http://www.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/en/ or can be found using virtual observatories.

The general problem of photometric surveys is that practically each survey or project has its own format of data. Researchers spend a lot of time not only searching the data for selected target(s), but also transforming them into a simple useable format in which they can compare measurements. The time stamps of measurements are, for example, given in somewhat modified Julian Date, numbers of seconds from the beginning of the project measurements and brightness of objects are given in (relative) magnitudes, fluxes or counts.

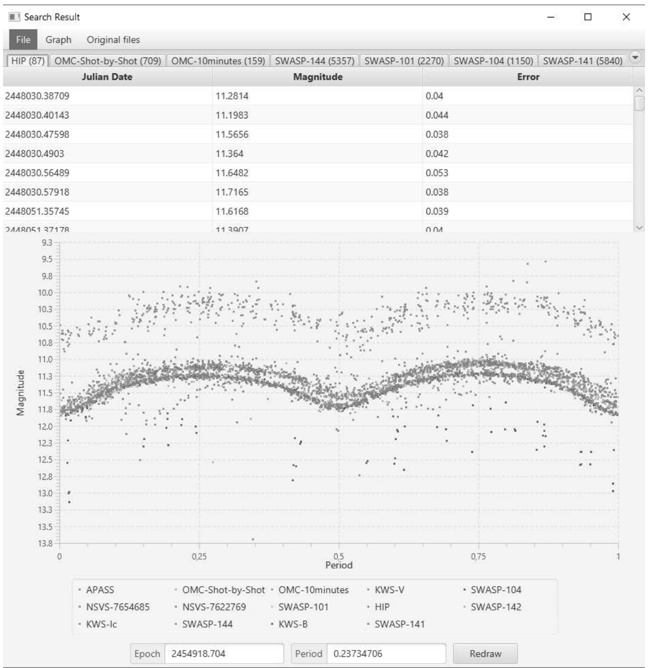

Figure 1. The example of visualisation of the result of data search for RW Com.

To increase efficiency of obtaining data, we developed a tool PDR (Photometric Data Retriever) which searches data in selected surveys and if any data are found, then transform them. Right now 15 surveys are bundled with PDR[1],

[1]The surveys included in a PDR search are noted by asterisks in the above given list. PDR also searches in the data archive of the Danish 1.54m telescope at La Silla http://vos2.asu.cas.cz/extract_dec17/q/web/form.

but it is possible for the user to write a plugin for a new survey and add it to the list. It is possible to search for a star by its name or coordinates and radius. The application gathers data from services such as SESAME and VSX to get as many aliases as possible, as well as other information about the object. After that it uses survey plugins to search for photometric data on the surveys APIs and websites. Data from surveys are transformed into a uniform format and shown to the user in a list with graph (of a phase curve for periodic variable stars).

A user obtains data in a uniform Julian Date format, magnitude, and error. No additional correction is applied to the time stamps, thus if original data are with heliocentric/barycentric correction, PDR gives heliocentric/barycentric Julian dates. PDR calculates magnitudes from given fluxes or takes them as they are published in the survey. Original data downloaded from the survey is stored as well and can be easily accessed through the application. All the data found can be exported in multiple ways.

To run PDR you will have to have Java 8+ installed on your computer. The application itself is platform independent, but as of right now there is only the Windows installation package available. It is possible to run the app on Linux or MacOS, it's just not that simple. The application is still under development. The latest version is always available on `https://github.com/m-krajcovic/photometric-data-retriever/releases`. The application will automatically update when a new update is available. The only known problem in some searching of data is matching the requested object with objects in surveys, because an astrometry from different surveys is slightly shifted in some cases and also coordinates given in SESAME differ from those at SIMBAD or VSX. The system is still in development. Any assistance, notes or recommendation are welcome.

3. Combine own measurements with found data

Obtaining data is only part of the common task. The other one is how to save and handle the data. We develop the Archiv of Measurements of PERiodic variable stars (AMPER), which is available for free at `http://amper.physics.muni.cz/`. AMPER can serve as a personal observational diary or a database for teams that need to share data hidden from non-members. It is possible to save one's own measurements, data from surveys or publications. AMPER offers visualisation of data in phase light curves as well as several tools, such as tools to show object visibility or to determine the timings of minima for eclipsing binaries. The database is still under development and it is upgraded regularly. The new users are welcome.

Figure 2. An example of the dataset for a star in the AMPER database.

4. Conclusion

We introduced tools for variable star researchers such as PDR – a tool for data search in a selected survey and their conversion into the uniform style and website service AMPER for saving photometric data. Both applications are still under development and any recommendations and notes are welcome.

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