

Web interface for star databases of the *Pi of the Sky* experiment

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ABSTRACT

The *Pi of the Sky* experiment, located at Las Campanas Observatory in Chile, searches for rapidly changing optical objects such as optical counterparts of Gamma Ray Bursts. The system consists of two CCD cameras placed on parallactic mount and operated by a PC equipped with dedicated software. The data acquired is reduced and essentially only the brightness of stars is stored in the database. A web interface for the star databases offers easy and quick access to the experiment's data and to other star catalogs that are also stored in our databases.

Keywords: *Pi of the Sky* experiment, sky survey, stars database, star catalog, light curve, web interface.

1. INTRODUCTION

The *Pi of the Sky* experiment [1] looks for short optical transients in the sky caused by astrophysical objects. For that purpose specialized Charge Coupling Device (CCD) cameras have been designed and build. In the current phase there are two cameras observing the sky each night and taking pictures every 12 seconds. The exposition itself lasts 10 seconds. In the remaining two seconds data transfer is performed. On average there are 11 hours of data acquisition per night, which amounts to over three thousand frames (of size 8MB each) per camera. The pictures are analyzed online and searched for point-like flashes. Precise sky pictures are useful for studying other astronomical phenomena as well. However this large stream of data cannot be stored on a computer system of reasonable size and cost. Even if it were possible, data analysis on raw sky images would be rather complicated and time consuming. To reduce the data and to prepare it in a simple, easy to analyze form, the pictures are processed offline and the most important information is stored in relational databases [2]. This data includes for instance stars brightness, their celestial coordinates, the coordinates on the CCD chip and the time of observation. In the database, which contains observations from the years, 2004-2005 there are about 800 million brightness measurements of about 2 million stars.

The brightness measurements are accessible online through a web interface. The interface allows one to search stars by their parameters (magnitude, coordinates, etc.) and view a light curve of a selected star. The interface can also be used to access other star catalogs, provided that the underlying database has the same schema as in the *Pi of the Sky* experiment. The data of ASAS [3], Tycho [4] and GCVS [5] catalogs were imported to such a schema and can now be browsed with our interface. The interface allows a user to switch between catalogs, for example to compare data of the same star.

The rest of this paper describes the functionality and implementation of the web interface. Section 2 contains a description of the database schema of star databases. Section 3 introduces the web interface. Section 4 describes how stars can be selected. In Section 5 there are details concerning the web page dedicated to a single star. Section 6 portraits the link with other star catalogs. Finally Section 6 concludes the paper.

2. DATABASE SCHEMA

The schema of a star database of the *Pi of the Sky* experiment is presented in Figure 1. The measurements of stars magnitudo are placed in the `Measurements` table. The properties of each measurement are celestial coordinates of the star, the time where the picture was taken, the measured magnitudo, the CCD coordinates, and others. A measurement is connected to a star of the `Stars` table. An entry in the `Stars` table describes star with parameters

such as its celestial coordinates and mean brightness. Each camera has its own list of stars. This separation facilitates processing of measurements of only one camera. This may be necessary if, for instance, one camera fails and gives incorrect or imprecise data (this was the case in the Pi of the Sky experiment; in 2005 a shutter in one camera broke down and then the camera operated with constantly open shutter). Finally, the table *Superstar* merges the information from the *Star* table to provide a single entry for each physical star.

The database is optimized for fast queries and it contains a lot of redundant information, such as mean magnitude of a star (calculated from magnitude of its measurements), mean magnitude of a superstar (weighed magnitude of stars associated with this superstar), position of stars and superstars, number of measurements per star, etc. This information is frequently used in queries selecting particular stars for further analysis. Had they not been precalculated, the queries that use these values would have been unbearably slow. Other speed optimizations involve indexes and released constraints. These databases are optimized for fast data access and not necessarily for fast loading of new information.

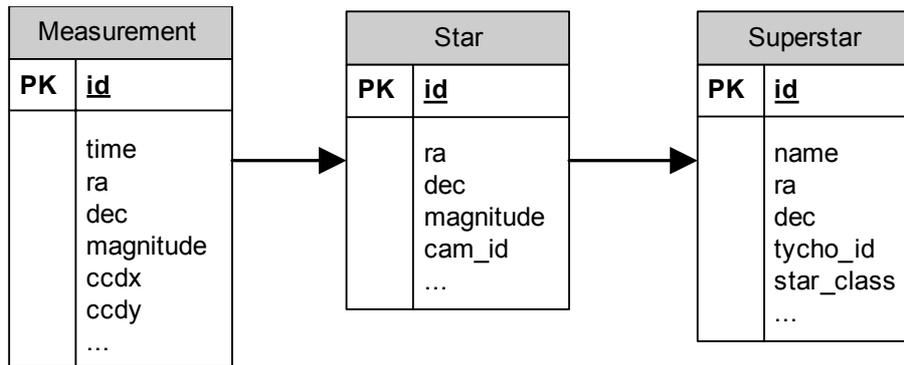


Figure 1. Database schema.

3. WEB INTERFACE

The web interface is based on the *Apache* web server [6], *php* server scripting language [7], *Smarty* template engine [8] and *javascript* browser scripting language. For generating plots JpGraph [9] library for php is used. There are two main use-cases for the web interface, described in the next two sections: searching for stars with given parameters (Section 4) and browsing data of a single star (Section 5).

4. STAR SEARCH FORM

The search form allows a user to search a star catalog for stars of given parameters. A user fills in the search form presented in Figure 2. It is not necessary to provide all parameters. The checkbox on the left of the each parameter may be checked or unchecked dependently on whether the parameter is to be used for searching. There are also advanced search options (hidden in Figure 2) for searching stars of a specified type, e.g. RR Lyrae variable stars.

After filling in the form, a user has to chose how the results will be presented by clicking one of the buttons “List stars”, “Show map”, or “Count stars”. The first choice will output a list of stars, as presented in Figure 2. The list is limited to the number of stars chosen from the “Stars per page” dropdown button. The complete list can be browsed by using the “next page” and “previous page” buttons, which cause fetching the next and previous portion of stars from the server. This limit was introduced for efficiency reasons. The table can be sorted in several ways, e.g. by magnitude, number of measurements, star’s name. The order can be chosen from the “Sort by” dropdown button (Figure 2). Clicking on an identifier of a star brings in the page of the star (see Section 5).

If the user clicks on the “Show map” button, the server will generate two plots (Figure 3): a *Sky map* – a plot with celestial coordinates Ra and Dec on the axes – and a *Variability Diagram* – a plot of the standard deviation of magnitudo measurements of stars versus their average magnitudo. These plots contain also a limited number of stars. Browsing and sorting can be done in the same way as in the case of the list of stars. Both plots are interactive. If the user selects an area by drawing a rectangle with a mouse, the plot will be zoomed in, i.e. a new query with new parameters will be executed on the server. The new coordinates will also be put into the search form (Figure 4). It is also possible to click on a star on the plots. If there are other stars close to the point where the user clicked, in the range of a few pixels, the plot will be zoomed in and centered on that point. If, however, there is no ambiguity which star was selected, the page of this star is presented (Section 5).

Finally the third option on the search form returns just the total number of stars found. The reason for separating this option from the other two is efficiency. If the number of records found in the database is large (millions) it is faster to retrieve a portion of data than to compute the total number of rows found.

Go to another database ▾
Pi Stars Browser
Database: Full database 2004-2005

[Tycho-2](#)
[GCVS](#)
[ASAS](#)

Show star:

% - replaces any string
 * - replaces one character

Searching:

Give the search parameters. Check the checkbox on the left of each parameter if that parameter should be used for the search.

| | | | |
|--|--|---|---|
| <input type="checkbox"/> Ra | min <input type="text" value="00:00:00"/> | max <input type="text" value="24:00:00"/> | ? |
| <input type="checkbox"/> Dec | min <input type="text" value="-90:00:00"/> | max <input type="text" value="90:00:00"/> | ? |
| <input type="checkbox"/> Search around | | radius [arcsec] <input type="text"/> | ? |
| <input type="checkbox"/> Magnitude | min <input type="text" value="0"/> | max <input type="text" value="15"/> | ? |
| <input type="checkbox"/> Error [mag] | min <input type="text" value="0"/> | max <input type="text" value="1"/> | ? |
| <input checked="" type="checkbox"/> No. observations | min <input type="text" value="400"/> | max <input type="text" value="500"/> | ? |
| <input type="checkbox"/> Amplitude [mag] | min <input type="text" value="0"/> | max <input type="text" value="100"/> | ? |
| <input type="checkbox"/> Period [days] | min <input type="text" value="0"/> | max <input type="text" value="100"/> | ? |
| <input type="checkbox"/> + Advanced | | | ? |

<< previous page
Sort by:
Stars per page:
next page >>

| List of Stars | | | | | | |
|-------------------------------|-----------|-------------|-----------------|---------------|------------------|-------|
| Id | Magnitude | Error [mag] | Amplitude [mag] | Period [days] | No. observations | Class |
| 073918+0519.9 | 3.280 | 0.000 | | | 484 | |
| 140639-3621.8 | 3.318 | 0.228 | | | 485 | |
| 163010-3417.8 | 3.370 | 0.262 | | | 441 | |
| 160021-2237.4 | 3.421 | 0.239 | | | 422 | |
| 132511-1114.5 | 3.480 | 0.200 | | | 454 | |

Figure 2. Web interface – search form with a list of stars.

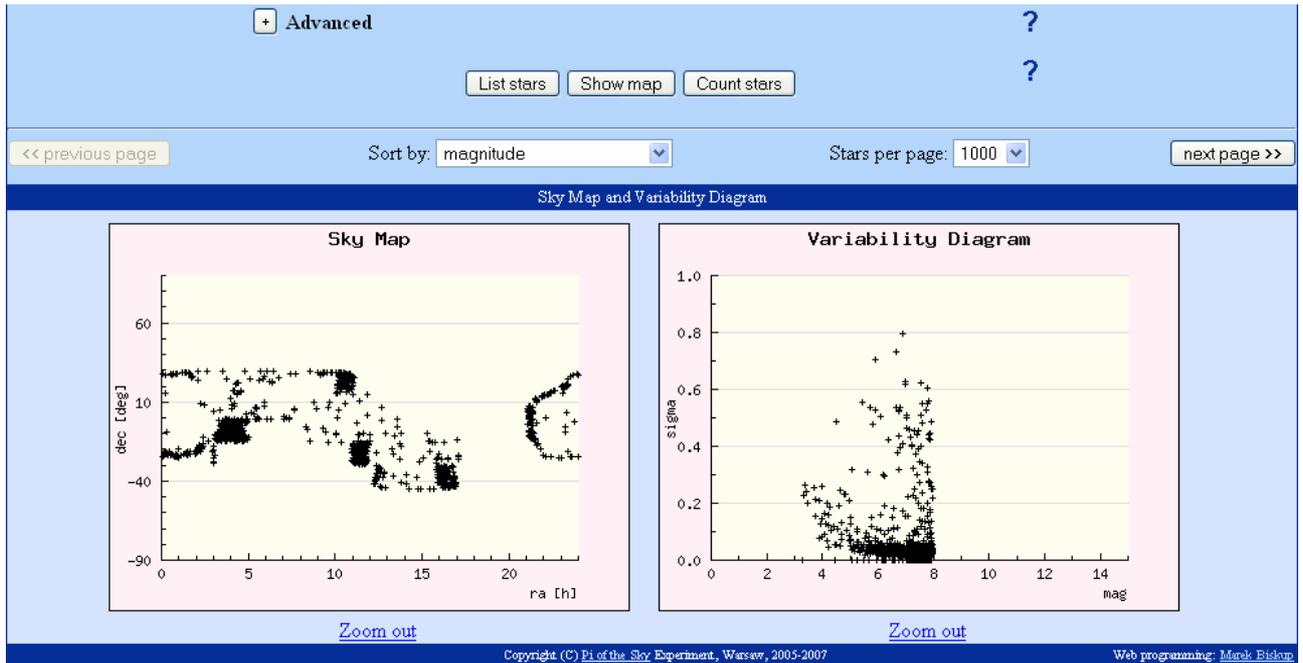


Figure 3. Web interface - sky map and variability diagram.

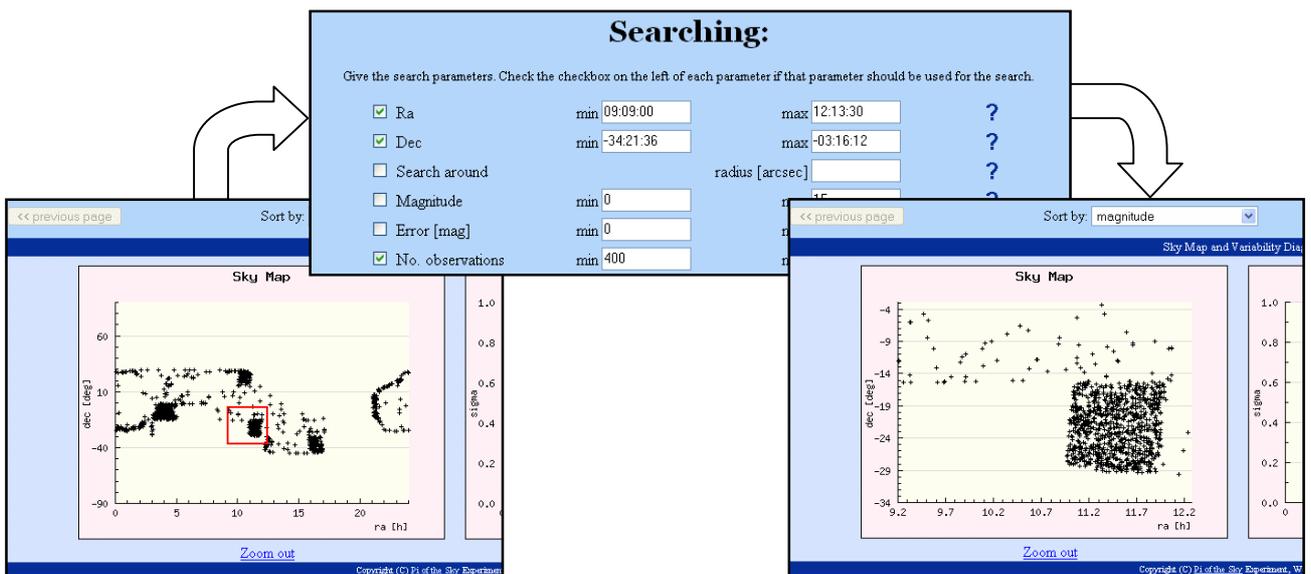


Figure 4. Interactive zoom on the Sky Map.

5. STAR PAGE

A star page of the web interface (Figure 5) is shown when a user selects a star on the list of stars or on a plot. The main part of that page is a light curve, i.e. a plot of measured magnitude versus time. In the Pi of the Sky experiment the sky is divided into a number *fields* of observation. The measurements from different fields are marked with a different color

on the light-curve. It is often necessary to distinguish different fields because observations of a star may have different characteristics (e.g. a different dispersion) on each field, depending for example on the position of the star on the CCD chip. For instance, measurements that are close to the center are more precise. The plot also shows the data of the other camera. Those observations are marked with small dots.

Parameters of the light curve are controlled using a form below the plot (see Figure 5). Apart from changing the range of data for the plot, a user may also draw a phased light-curve – a light curve where the time axis is taken modulo a given period (the *Period* parameter in the form). On such a plot the points are repeated twice to show two lengths of the period. Phased light-curves are useful when studying periodic variables. It is also possible to plot averages of a given number of consecutive measurements (the *Merge* parameter in the form). This option may be used to remove the influence of statistical errors to reveal true changes in a light-curve. The form allows also some erroneous measurements to be skipped (the *Skip* <NNN> options in the form) – turning on these options will cause measurements, which are marked in the database with an appropriate flag to be removed from the plot. The option *Field* may be used to choose one or more fields of observation, separated by a comma, from which the measurements will be shown. The light-curve is zoomable in the same way as the Sky Map and the Variability Diagram. After selecting a region, it will be magnified (Figure 6). Such a zoom corresponds to setting new range in the form.

The changes to a light-curve caused by setting different parameters in the form or by the interactive zoom are done asynchronously in JavaScript. The whole web page is not downloaded again from the web server – only the picture with the plot is reloaded. Such a solution speeds up browsing and reduces server loading. This solution does not destroy the browser's back button functionality. Bookmarking however will not work directly and the whole web page should be reloaded with new parameters before saving the URL of the page. This can be done by clicking on the Reload Page button just below the light-curve (see Figure 5).

The data from the plot can be exported in a few file formats: as a HTML table, in a Comma Separated Values (CSV) file and as a ROOT macro. The CSV file contains also the metadata of a plot, for instance the values of the parameters of the form. The ROOT macro is a macro of the ROOT framework [10] that plots the light curve in a nice, ready-for-publication way. A user may choose to export only a basic data – time and value – or also additional information of each observation – the celestial coordinates, the coordinates on the CCD chip, the field, etc.

Apart from the light-curve, the star page contains detailed information about a star. For instance there is a link to the same physical star from the other camera and a link to stars in external databases (see Section 6). Advanced properties are initially hidden. They will be shown after the user clicks on the *Advanced* button. Showing and hiding of these properties is done in JavaScript and does not involve any communication with the server.

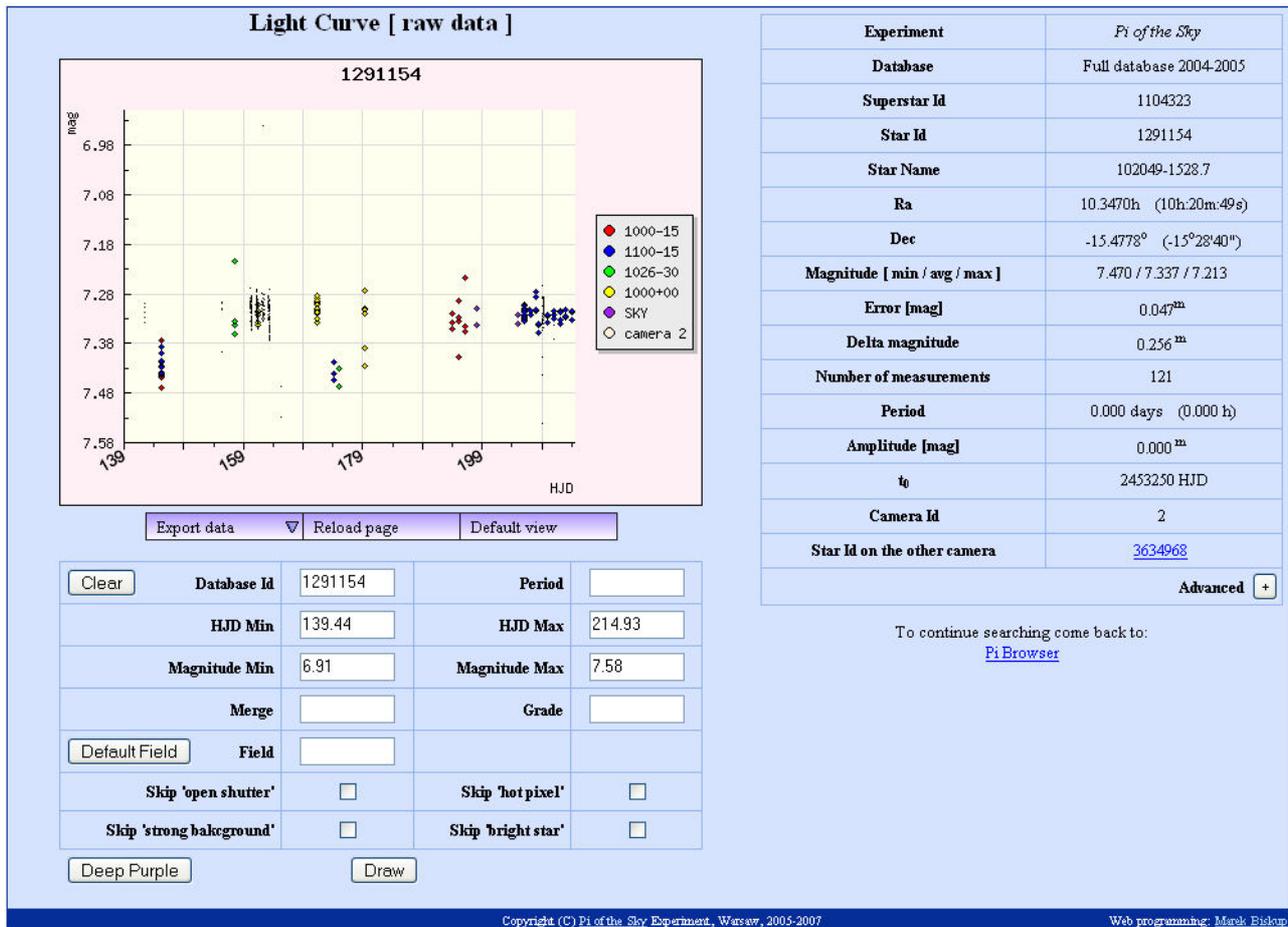


Figure 5: Star page.

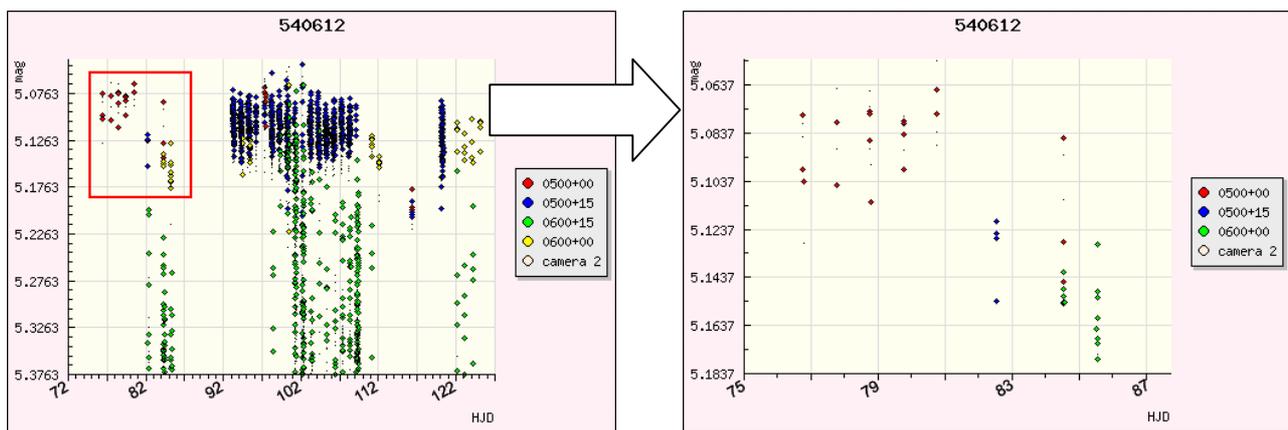


Figure 6: Interactive zoom of a light curve.

6. OTHER STAR CATALOGS

It has been mentioned before that the web interface can be used with other star catalogs, provided that the database scheme is the same. The data of ASAS [3], Tycho [4] and GCVS [5] catalogs have been loaded into such databases. Together with the Pi of the Sky data they form a large system, which allows the catalogs to be changed easily. First of all the user can switch between databases by choosing a database from the DHTML popup menu on the star search form (Figure 2 – upper left corner). Also on a star page there are links to the page of the same star in other catalogs (provided that this star has been correctly identified in other catalogs – the identification is stored in the `superstar` table). There is also a link, which presents results of searching for stars in the range of 2 arc minutes around the position of the current star.

The data of each catalogue differs a bit. For instance in the Tycho and GCVS catalogs there are no brightness measurements. Also the variability types in GCVS and ASAS are different. The web interface is fully configurable and such changes can be described in configuration files, without any modification to the source code.

6. SUMMARY

The “Pi of the Sky” experiment is constantly growing and the amount of data gathered is larger and larger. The data is accessible through a dedicated web interface, which facilitates searching and browsing. Also other star catalogs have been imported into our databases to provide easy and consistent access to all this data.

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