A Short Tutorial on Finding Information on Astronomical Objects.

This document is intended to help outline the available resources that astronomers use to find out information about specific astronomical objects. The number of available online astronomical resources is enormous, and I have not tried to be complete. Rather I have written this from the point of view of the Blue Objects for Kepler Observing (BOKO) project.

Project Goal:

A UBV ground survey of the Kepler field has identified a few hundred very blue objects of an unidentified nature. The goal of this project is to collect as much information about these objects from the available online astronomical resources and attempt to classify and/or identify these blue sources. All we know about the blue sources are their coordinates (right ascension and declination) and optical (UBV) brightnesses. We would like to match these sources to other astronomical catalogs and build spectral energy distributions for each of these objects and attempt to classify the objects. Brightness measurements in the x-rays, ultraviolet, optical and infrared will collected from online resources such as ROSAT, GALEX, USNO-B, 2MASS, and WISE databases.

Background on Coordinate Searches:

The most fundamental units used for astronomical identification are on-sky coordinates, and it is the coordinates that you will use (almost exclusively) to acquire information on these blue objects. Thus, I thought I should take a moment to discuss the coordinates and some practical details of coordinate searches.

There are three basic coordinates systems used in astronomy: equatorial (right ascension and declination), galactic (longitude and latitude) and ecliptic (longitude and latitude). A comprehensive (and a little advanced) overview of the three systems and how they relate to each other can be found at

http://spider.seds.org/spider/ScholarX/coords.html

For our purposes here, all coordinates will be in the equatorial system (ra, dec). Most online services assume you are using equatorial coordinates and, thus, you usually do not have to declare what system you are using unless you change from equatorial coordinates.

Typically, the sexagesimal form of the right ascension is listed in hours (h), minutes (m), and seconds (s) and is displayed in a variety of formats but most commonly as

HH:MM:SS or HH MM SS or HHhMMmSSs
Example: 19:30:45 or 19 30 45 or 19h30m45s

Declination is listed in a similar fashion: degrees (d), minutes (m) and seconds (s).

DD:MM:SS or DD MM SS or DDdMMmSSs
Example: -19:30:45 or -19 30 45 or -19d30m45s

In a typical search form found at astronomical data sites where you are searching for one object at a time, the coordinates can be entered in any of the above formats as long as they are consistent; i.e., the format of the right ascension and the declination are the same.

However, many of the services allow a user to upload a long list of sources. These table uploads are usually significantly less forgiving in the allowed formats and many ONLY allow right ascension and declination coordinates that have been converted to decimal degrees

RA (decimal degrees) = (HH + MM/60. + SS/3600.)*15.

The 15 is the result of there being 15 degrees in 1 hour of right ascension (24 hours = 360 degrees).

Dec (decimal degrees) = +/-(DD + MM/60. + SS/3600.)

When converting negative declinations to decimal form, remember to only apply the negative sign AFTER you have done the decimal calculation.

Because they are single numbers, decimal degrees are significantly easier to handle in a various forms than the sexagesimal form of coordinates. Spreadsheets such as excel tend to convert sexagesimal formats into "time" and typically do this incorrectly. Further, the fact the sexagesimal forms can be delimited by spaces, letters, or colons makes parsing the coordinates difficult.

So be aware, depending on the service, you may be required to use decimal degrees while other services may be more flexible. But converting to decimal degrees early on and sticking to decimal degrees may save you a large number of headaches in the end.

Positional Searches and Search Radii

The typical search that you will do will be to input a coordinate (position) and a search radius. The services will then search around that position and return all objects that match your inputted position within the limits of your search radius.

Experience plays a key role here in understanding what is returned by the positional searches; some of that experience and knowledge is hard to quantify and impart, but here are some general guidelines that may help.

1. The larger the search radius the more objects you will get to match your positional search. This may seem obvious, but there is a balance with

making the search radii large enough to return something useful and too large that completely unrelated objects are returned in the search, misleading you into thinking you have a real match.

2. Typically, when multiple matches are found, the closest match is the one you want.
3. It is possible that you will not find a match for a set of objects unless you make the search radius very large – but those matches may not be real.
4. Setting a good search radius is a difficult thing; a good search radius is typically akin to the quality of the astrometry that went into the coordinates. You may have to play with this depending on what you find, but if you find a coordinate match that is within 1-2” of your input coordinates then that is very likely to be a real match (maybe).
5. Coordinate matching alone may not yield the right answer. Even if the distance between the input coordinate and the matched source is less than 1”, that does not guarantee that the matched source is the correct astrophysical source.

Are the Objects Already Identified?

Before trying to collect a slew of data and trying to interpret the data, it would make a lot of sense to see if someone else had already identified the object. The most comprehensive database of ‘known’ astronomical objects is SIMBAD

http://simbad.u-strasbg.fr/

SIMBAD allows searches by coordinates – that is, is there a known object within XX arcsec of a position. You can enter one coordinate at a time or upload a list of coordinates at

http://simbad.u-strasbg.fr/simbad/sim-fcoo

This service requires a two column list of right ascension and declination in decimal degrees. No other information can be in the file. The service will return ALL objects found within the search radius specified. So choice of a search radius is an important consideration (see above). SIMBAD will not tell you what the best match is; it will only tell you what sources matched within the given search radius and how far the matches are from the search position.

If the object is found in SIMBAD and it matches to within a 1-2”, it is likely the true source that is matching your input coordinates. Beyond 10”, the match is likely not correct and a match between 2-10” away deserves a closer look.

Places to Start

The following is a short list of places to start for the raw collection of data. While all (or most) of the objects in the test list should show up in SIMBAD, you should run them all through the following the sites, so you have an idea of how these sites work and what kind of output they provide.

Ultraviolet Observations

The GALEX satellite is a far-ultraviolet and a near-ultraviolet mission (http://www.galex.caltech.edu/). The satellite did a partial survey of the Kepler field so some of our objects may have been observed by Galex. There is an interface to those data at http://galex.stsci.edu/GalexView/

The service will return a Far-UV and Near-UV magnitude and error along with a bunch of other information.

Optical and Near-Infrared Observations

While optical astronomy has been around the longest, there are NO good optical surveys of the entire sky and getting good optical magnitudes of random objects in the sky is typically very difficult. In contrast, near-infrared astronomers have been much more careful and have mapped the entire sky at multiple wavelengths. The ground-based survey 2MASS covered the entire sky in the near-infrared filters JHK (wavelengths 1 - 2 um).

A good place to start is the Kepler Input Catalog Survey (KIC) at MAST. The KIC survey was a dedicated optical ground based survey for target selection for the Kepler mission. A web based interface to the KIC, including the ability to upload a list of coordinates can be found at http://archive.stsci.edu/kepler/kic10/search.php The survey combined optical observations with the near-infrared 2MASS magnitudes. So if the object appears in the KIC it will have optical and 2MASS near-infrared brightness measurements.

Looking at Fields

Sometimes you just want to see an image of the field to see if there is anything there at in the optical and/or near-infrared. A useful service to do this is the Finder Chart service at http://irsa.ipac.caltech.edu/applications/FinderChart/. Here you can upload a list of coordinates and it will return small 5 arcminute finder charts of the piece sky centered on the position. It pulls images from the optical photographic sky survey and the near-infrared 2MASS sky survey.

The optical sky survey images provide very poor photometry BUT go fairly deep and should allow you to see if the objects are detectable and perhaps have give you a chance to see if they look like a galaxy or something. The 2MASS images just provide another look at the field, but if the objects have 2MASS detections then they likely will show up in the KIC search (see above).

One Final Set of Caveats

All of these services were written with astronomers in mind and with very limited funding. Thus, sometimes the services can be confusing or unclear. Try not to get frustrated; if you have a question about the service or how to use, you can use Steve and me as a resource, but feel free to email/contact the help desk associated with the individual services. Astronomers who really understand the individual services man those services and should be able to answer most of your questions. Early on in this project, it will be unclear to you what information being returned is useful or ancillary. Track those questions and we can try to address those as we go forward.