

Real astronomy data for anyone: Explore NASA's IRSA

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Many professional astronomy archives are open to the public; software tools are getting better all the time to not just access these data, but also work with them.¹⁻² The Infrared [IR] Science Archive (IRSA)³ is NASA's home for long-wavelength data, both space- and ground-based. You can use this interface to pull data to create your own lessons, or turn students loose in the archive to discover features of our multi-wavelength universe.

Archives designed for professional astronomers must be usable by *all* astronomers, from a summer student embarking on her first-ever research project through the emeritus professor who can barely read his email. This means that anyone can access it, though they may need to learn some vocabulary and tools. The archives are in the middle of a fundamental shift from “give me the data and let me take it home to analyze” (which means you have to write all your own code) to “do some or all of the analysis at the archive itself and give me only a subset of the data – or even just plots – to take home” (see, e.g., Ref. 2). The tools are improving as a result of this shift (driven by ever larger data sets), though admittedly the tools are not fully user-friendly yet. However, they have reached a stage where it is worth your time to get in there and explore.

There are many astronomy archives out there, as distinct from planetary or solar. There are more U.S.-based astronomy archives than international ones, and there are archives for both space-based and ground-based data, often divided by the funding source. IRSA is just one of NASA's astrophysics archives, and currently holds some of the largest data sets: 3 petabytes (PB) of imaging data and almost a trillion measurements, including over 200 billion rows of catalogs.⁴ These data sets have been important for ~1500 to 2000 refereed journal articles for each of the last several years, or an average of at least ~5% of the world's astronomy journal output. There are a lot of data to mine at IRSA!

IRSA has lots of online help and even tutorial videos on our YouTube channel (<https://irsa.ipac.caltech.edu/docs/how-to/tutorials.html>). You can't damage anything, and the tools allow you to interact directly with FITS images (a professional astronomy image format) and catalogs to make plots. You just need a browser (Firefox or Chrome recommended) and an internet connection.

The major data sets in IRSA in which you are likely interested are 2MASS (a ground-based, near-IR, all-sky survey⁵) and WISE (a space-based, mid-IR, all-sky survey⁶). Both of these surveys include images and the catalogs derived from them, so you can retrieve images and make three-color imag-

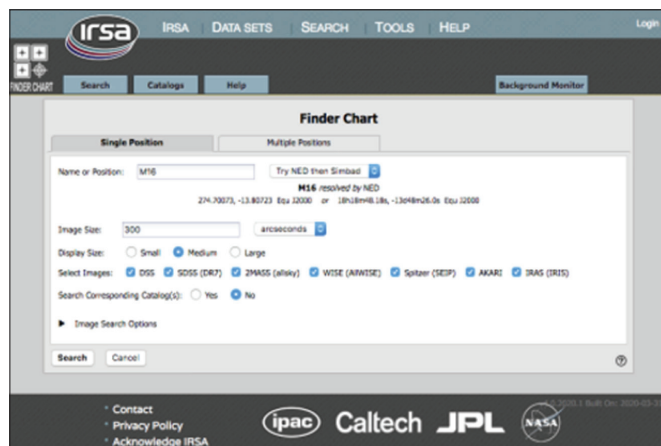


Fig. 1. The Finder Chart search screen, filled out to ask for 300-arcsecond-wide images of M16 (the Eagle Nebula), from optical (DSS, SDSS) through near-infrared (2MASS) to mid- and far-infrared (WISE, Spitzer, Akari, and IRAS). Note that the “search corresponding catalog” option is set to “no” here.

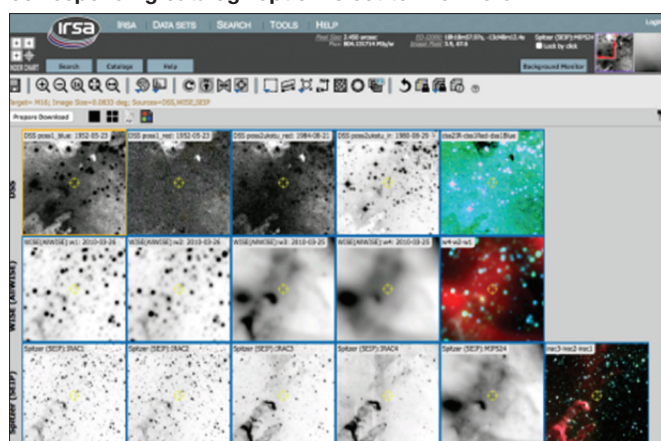


Fig. 2. The results of the Finder Chart search from Fig. 1, showing that the “talons” of the eagle are dark in the optical but brighter in the mid-IR.

es, but you can also retrieve catalogs and make color-magnitude and color-color diagrams.

A good starting tool is Finder Chart⁷ because it gives you the same field at various wavelengths from several different surveys, optical through infrared. An example search screen for Finder Chart is shown in Fig. 1. (You can ask it to search the catalogs at the same time as images, but I recommend turning off catalog searching until you are ready for it.) You can have Finder Chart create three-color images. An example lab might involve exploring how various kinds of Messier objects (star-forming region, galaxy, open cluster, globular cluster) compare across wavelengths from optical to far-infrared, and over time (from the technology in the 1950s to 1980s through the mid-2010s). Figure 2 shows the results of such a query for the Eagle Nebula. You can have students grapple with questions such as: Which objects are bright and which are not? How do the stars and nebulosity compare? Why do

some of the oldest IR data have such obvious pixels? If you find a target that moves, like Barnard's Star, you can watch it move from the 1950s through 2010, and calculate its proper motion.

When you are ready to include catalogs, you can use Finder Chart to retrieve the catalogs and make plots of the source characteristics it retrieves, or you can initiate a new search in other catalogs held at IRSA (or found elsewhere on the web). It overlays the catalog on the image and makes a plot—you can change what is plotted and do simple mathematical manipulations of the columns to plot. The catalog, plot, and images are all interlinked, such that if you click on a source in the plot, it is highlighted in the image and catalog too. One of the IRSA video tutorials⁸ demonstrates in ~three minutes how to take the Gliese-Jahreiss list of nearby stars,⁹ retrieve a Gaia¹⁰ catalog for those stars, and make a color-magnitude diagram, correcting the magnitudes individually for distance. It will look very much like HR diagrams in textbooks! You can then click on sources in the plot to identify specific nearby white dwarfs and giants in the catalog.

We do not—yet—have “cookbook labs” for these tools. We are developing some as part of NITARP, the NASA/IPAC Teacher Archive Research Program. What we have is collected on the web.¹¹ We hope to add more labs in the future, but in the meantime, a whole universe is available for anyone to explore!

References

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3. <http://irsa.ipac.caltech.edu>.
4. The term catalog refers to a database of measured stellar characteristics, such as brightness.
5. 2MASS is Two Micron All Sky Survey, <https://irsa.ipac.caltech.edu/Missions/2mass.html>, M. Skrutskie et al., “The Two Micron All Sky Survey (2MASS),” *Astron. J.* **131**, 1163 (2006), <https://ui.adsabs.harvard.edu/abs/2006AJ...131.1163S/abstract>.
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7. <https://irsa.ipac.caltech.edu/applications/finderchart/>.
8. <https://youtu.be/IGQB8a4YY4U>.
9. See specifically Stauffer et al., “Accurate coordinates and 2MASS cross identifications for (almost) all Gliese Catalog star,” *Pub. Astron. Soc. Pac.* **894**, 885 (2010), <https://ui.adsabs.harvard.edu/abs/2010PASP.122..885S/abstract>.
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Fermi Questions

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► Question 1: Snow volume

How much snow falls on the U.S. each winter?

► Question 2: Longbow arrow velocity

Arrows from English longbows could penetrate plate armor. What is the velocity of an arrow shot from an English longbow?

Look for the answers online at tpt.aapt.org under “Browse,” at the very end of the current issue.

Question suggestions are always welcome!

For more Fermi questions and answers, see *Guesstimation 2.0: Solving Today's Problems on the Back of a Napkin*, by Lawrence Weinstein (Princeton University Press, 2012).

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