Large-Scale Surveys of Nearby Molecular Clouds with NEWFIRM Assisted by Quick-Reduce Pipeline

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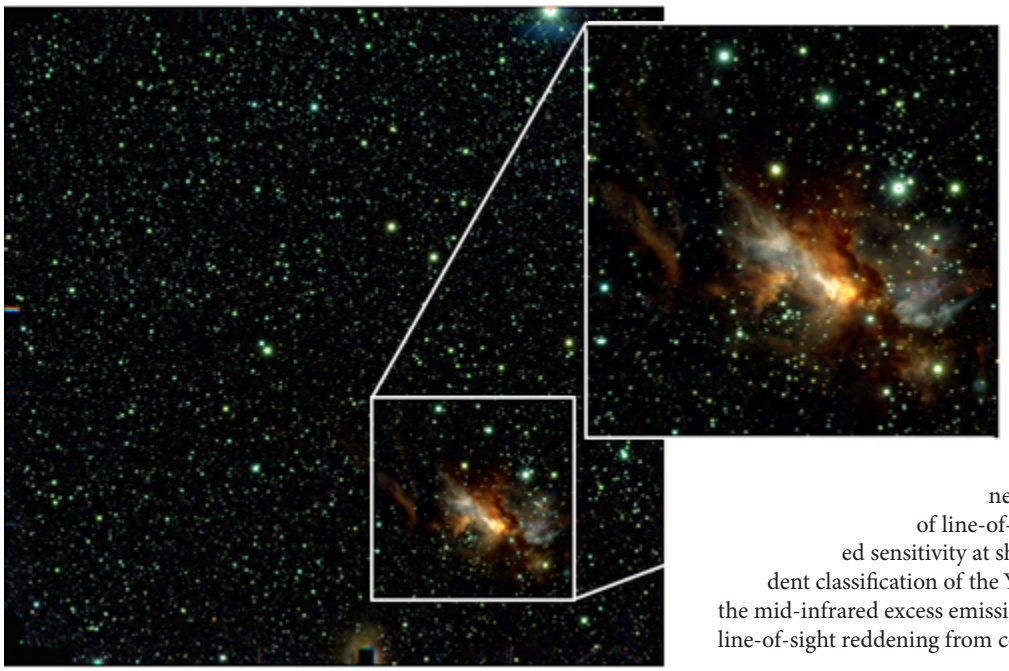
The NEWFIRM wide-field near-infrared imager has seen heavy use at the Kitt Peak Mayall 4-meter telescope throughout both the spring and fall semesters this year, aided by an effective quick-reduction data processing pipeline that gives observers extra insight into the quality of the ongoing observations.



In semester 2008A, NEWFIRM was heavily used for extragalactic deep-field programs (for example, see the article from Pieter van Dokkum and colleagues in the June 2008 NOAO/NSO Newsletter). The fall semester saw more galactic programs, including a survey of the nearby, high-mass, star-forming molecular clouds, Cep OB3, MonR2, and S140 by Rob Gutermuth and colleagues, which takes full advantage of NEWFIRM's wide field of view to map large areas to previously unachieved depths.

Gutermuth's program is meant to supplement previous Spitzer mid-infrared surveys of these regions. The primary goal is to uniformly identify and classify all young stellar objects (YSOs) in these clouds with excess infrared emission from their warm inner disks. By combining these results with similar surveys of other nearby clouds (such as those surveyed by the c2d and Gould Belt Spitzer Legacy surveys), the team hopes to understand how star formation is initiated, regulated, and terminated in molecular clouds, and how the different star formation environments in such clouds—clusters, groups, isolation—impact star and planet formation.

Gutermuth and his colleagues have used Spitzer data to identify and classify any YSOs with dusty circumstellar material down to the Hydrogen-burning mass limit, but measurements of the line-of-sight extinction towards any sources detected are predominantly obtained from ground-based near-infrared photometry. Until recently, the Two Micron All-Sky Survey (2MASS) was the only feasible source for uniform near-infrared photometry over such wide fields of view, and its shallow sensitivity has been a major limitation.

However, new, large-format, near-infrared imagers on 4-meter-class telescopes, like NEWFIRM, make it possible to observe the many square-degree areas covered by Spitzer to a near-equivalent depth over a wide range of line-of-sight dust column densities. This added sensitivity at shorter wavebands enables more confident classification of the YSOs, making it possible to differentiate the mid-infrared excess emission in the warm, dusty inner disks from line-of-sight reddening from cool dust in the natal molecular cloud.

Furthermore, the additional sensitivity of the NEWFIRM data permits the detection of many more background stars that can be used as probes of the projected spatial structure of the dense, star-forming material in the cloud as traced by the inferred dust column density. These "extinction maps" are some of the most robust column density tracers in star-forming molecular clouds. With the additional background stars to probe the cloud structure, the resolution and the dynamic range of these maps can be improved simultaneously. This should enable a more precise positional comparison between forming stars and their natal cloud.

The images illustrating this article (and on the cover of this *Newsletter*) were created by Gutermuth during his run, based solely on products generated by the NOAO NEWFIRM Quick-Reduce Pipeline (QRP). The only additional processing was combining the J, H, and K images based on the pipeline-generated astrometry to create the color composite picture. After each NEWFIRM observing sequence, the

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Large-Scale Surveys with NEWFIRM continued

QRP processes the data, performing dark, flat, and linearity correction. It carries out sky subtraction using strategies that depend on the observing sequence, e.g., running median sky frames for dithered sparse-field data, or offset sky images for sequences that alternate between target and background fields. In each field, 2MASS stars are used to derive an astrometric solution and photometric zero-point for the images, which are re-projected onto a tangent plane and combined into a stack, and delivered to the observer. The magnitude zero-point, seeing FWHM, and sky brightness are reported for each image. Web pages are generated reporting this information and providing preview images for all individual and stacked frames.

The QRP is not intended to produce science-ready data products. It takes several shortcuts designed to speed data processing, and it may not always have the best calibration data (e.g., flats and darks) on hand at the time an observation is processed. For the best processing, there is the Science Pipeline, which NOAO is commissioning during the 2008B semester. The Science Pipeline runs at the NOAO Tucson office, processing data after each observing run. It uses more advanced algorithms, such as second-pass sky subtraction with object masking, sophisticated outlier rejection when stacking images, latent image masking, and higher-order interpolation for image resampling. The Pipeline Team, an NOAO/University of Maryland collaboration, is now implementing and testing the last features of the Science Pipeline. The team expects to start providing processed data to principle investigators of NEWFIRM programs for science verification by the end of the year.

Meanwhile, the NOAO Mosaic Science Pipeline is now routinely processing data taken with the Mosaic CCD imagers at both KPNO and CTIO. The Mosaic pipeline is also undergoing a major upgrade to incorporate stacking of images taken with "mosdither" observing sequences. A two-pass procedure is used to identify and mask transient features (cosmic rays, satellite trails, etc.) before stacking.

By November, the new Mosaic pipeline will be reprocessing all 2008B Mosaic observations, and the data products will be delivered to the principal investigators. Currently, pipeline data products are staged to a password-protected ftp area for delivery to observers. However, the next version of the NOAO Science Archive will ingest and store pipeline data products, which then can be queried and retrieved in the same manner as is currently done for raw data. Reduced data will be available to the general community after the end of the proprietary period (normally 18 months). In 2009, all data from both Mosaic and NEWFIRM should be routinely processed through the pipelines, and the resulting data products will be archived.

Who Are the Users of the NOAO Archive?

Christopher J. Miller

The NOAO Data Products Program (DPP) operates the NOAO Science Archive and its services. Over the past year, DPP has added significantly to its arsenal of tools, data, and services available to principal investigators (PIs) and the community. Here are some highlights of the DPP products and services as they exist today:

- The legacy NOAO Science Archive enables the public to discover and access over 70,000 science-ready, PI-reduced images from 15 different NOAO Survey Programs.
- The new NOAO Archive provides PI access to raw Mosaic and NEWFIRM data.
- DPP's Mosaic pipeline automatically processes Mosaic data for PI evaluation.
- The NOAO Portal provides access to NOAO Survey data, Mosaic and NEWFIRM raw data, and Mosaic reduced data, as well as multi-wavelength imaging data from Virtual Observatory (VO) archives for HST, SDSS, Chandra, XMM, and others.

What does this mean for the NOAO user? For starters, there is a significant increase in the amount of NOAO data available to the community. At the same time, there is growth in user access to the Web sites and ftp areas that serve this data.

Currently, DPP supports access to NOAO archive holdings through two browser-based mechanisms. The NOAO Science Archive (*archive.noao.edu*) is the original (now legacy) access point to NOAO Survey data. The newer NOAO NVO Portal (*www.nvo.noao.edu*) provides access to the NOAO Survey data through a graphical interface as well as access to imaging data from VO archives for HST, SDSS, Chandra, XMM, and more. PIs use the NOAO Portal to access their Mosaic and NEWFIRM raw and reduced data.

Over the last two years, we have seen usage of the original NOAO Science Archive grow by 25 percent. On average, users from well over 1,000 unique IP addresses search for archival NOAO Survey data each month. These users also download hundreds of gigabytes of PI-reduced NOAO data per month.

We have seen even more dramatic growth in usage of the NOAO Portal (*portal-nvo.noao.edu*). Since its release in 2006, monthly access to the NOAO Portal has doubled to over 400 unique IP addresses

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Who Are the Users of the NOAO Archive continued

per month. Users return to the Portal an average of three times per month. In many cases, they are using the Portal to discover VO archival data. However, the bulk of the many hundreds of gigabytes of data-volume transferred from the NOAO Portal consists of raw data delivered to PIs from their Mosaic and NEWFIRM observations.

DPP is building the data management system that our community needs, both now and for the future. As the size of mirrors, the number of instruments, and the number of people in the astronomy community continues to grow, so will the need for effective management of the data that is produced.

At this juncture, input from the community is vital. What features does the community like? What features are missing? What enhancements could be made? This input can guide DPP in not only shaping the look and feel of the Archive and its Portal, and the quality of the pipeline reductions, but also in strengthening their scientific use for both PIs and the public. Please email your comments and suggestions to DPP at *vohelp@noao.edu*.

NOAO Staff at the NVO Summer School 2008: Faculty, Students, and Award Winners

Douglas Isbell

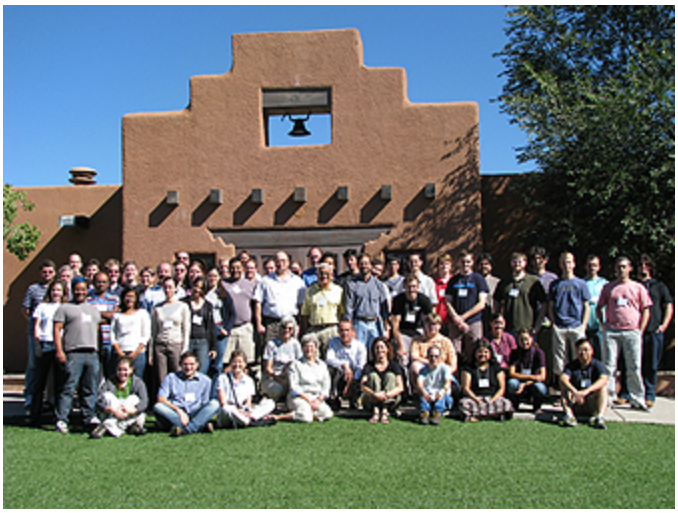
The 2008 summer school for the National Virtual Observatory (NVO) was held in Santa Fe, NM, September 3–11.

NOAO faculty at the summer school included Dave De Young and Mike Fitzpatrick from NOAO North, and Chris Miller from NOAO South; "students" hailing from NOAO included Ken Mighell, Katy Garmany, Irene Barg, Jerry Schneider, and Dick Shaw from NOAO North, and Exequiel Fuentes from NOAO South.

During the hands-on program, the participants became familiar with how to discover, access, visualize, and analyze data using the Virtual Observatory. In addition to exploring the various tools and data sets available through the NVO, all the students in the workshop worked in teams to complete a final project.

A group including Ken and Katy developed an education outreach-oriented project on the construction of color magnitude diagrams from online data, which won first place in the education category. The PDF version of the presentation, "Using NVO Tools for Astronomy 101," and detailed information for replicating the educational activity described in the presentation, is available at: *www.noao.edu/staff/mighell/nvoss2008/*.

The faculty presentations and student project talks are available at the NVO Summer School Twiki: *nvo-twiki.stsci.edu/twiki/bin/view/Main/SummerSchool2008*



NVO Summer School 2008 students and faculty in Sante Fe, NM.