University of Cincinnati Department of Physics

Cincinnati, Ohio 45221 www.physics.uc.edu

[S0002-7537(95)00901-2]

The following report covers the Department activities from July 2003 through June 2004.

1. PERSONNEL

At the University of Cincinnati, research in astrophysics can be broadly characterized as the investigation of young stellar systems and their environment, primarily at infrared wavelengths. The astrophysics faculty consists of associate professor Margaret Hanson, whose major research interest centers primarily around near-IR studies of young, massive stars and the massive clusters they form in, and full professor Michael Sitko, who works largely in the field of dust in comets and disks surrounding young intermediate- and low-mass stars.

In addition, a number faculty in the Particle Physics group (Philip Argyres, Paul Esposito, Peter Suranyi, Rohana Wijewardhana, and Louis Witten) are actively pursuing theoretical research in areas related to black holes and cosmology.

In January 2005, Hanson will begin serving as the Associate Editor for *The Astronomical Journal*. It is at this time that the Editor of the Journal will also change from Paul Hodge (U. Washington) to Jay Gallagher (U. Wisconson). Hanson was chosen because her science expertise in galactic studies (stars and interstellar medium) compliment the science background of Gallagher (extragalactic). The two will oversee all editorial services of the journal.

2. RESEARCH

2.1 Young Stars & their Environments

As part of a program supported by a grant from NASA's Origins of Solar Systems program, Sitko is collaborating with D. Lynch and R. Russell (The Aerospace Corporation) and C. Grady (Eureka Scientific) in a survey of the mid-IR (3-14 μm) spectral characteristics of dusty protostellar disks. The mid-IR data were obtained over the course of 9 years using the Aerospace Corporation's Broad-band Array Spectrograph System (BASS). The purpose of the program is to investigate the evolution of the grains during the epochs when planetary systems are developing. In all, over 40 pre-main sequence stars (Herbig Ae/Be stars and T Tauri stars) were observed. In many cases, multi-epoch observations have been obtained, in order to investigate the time-dependent changes in the structure of the innermost regions of the disks. To unravel the geometry of the disks, and the distribution of the dust within them, theoretical models are being applied to these and other available data.

Sitko has been working with N. Calvet (Harvard-Smithsonian Center for Astrophysics), E. Bergin (Univ. of Michigan) and other collaborators on investigating the inner disk regions of T Tauri stars. They recently completed the analysis of the disk structures surrounding four stars (GW Ori, GM Aur, DM Tau, and Lick Ca 15). These stars were found to exhibit emission due to H_2, probably due to a combination of fluorescence by Lα and impact excitation by high temperature electrons. Inner gaps of a few AU were found in the disks of these stars, whose ages are roughly 1 Myr.

Sitko and graduate student, William J. Carpenter have begun a program to model the global characteristics of the entire sample of objects. For handling such a large group of objects, the publicly-available DUSTY code (University of Kentucky) is being used. In a few cases, these results will be compared with those using monte carlo methods, in collaboration with Barbara Whitney (Space Science Institute). Sitko also collaborated with E. Polomski in her investigations of the dust composition and morphology of FU Orionis stars. Observations consisted of near- IR and mid-IR imaging, mid-IR spectroscopy, and submillimeter photometry. As a class, these objects form a very heterogeneous group. In one source, RNO 1C, disk-like structure has been resolved for the first time. Par 21 was found to exhibit significant emission features due to hydrocarbons, the first yet observed in this class of objects.

Hanson and Nicole Homeier (John Hopkins) completed a successful run in August 2003 on the *European Southern Observatory's*, 8-m, *Very Large Telescope*. They obtained high resolution, near-infrared spectra for young massive stars in the giant HII region, W49a. During the run they also obtained over 2 dozen spectra of stars in the massive galactic cluster, Westerlund 1. These spectra will support a *Hubble Space Telescope* program to obtain near-infrared images of Westerlund 1 by Hanson and Richard De Gris (U. Sheffield, UK) in 2005. A sophisticated kinematical study of the cluster will be undertaken using the n-body simulations of collaborators Simon Portegies-Zwart (U. Amsterdam, NL) and Steve McMillan (Drexel U.)

2.2 Solar System

For the past few years, Sitko has been collaborating with D. Lynch and R. Russell (The Aerospace Corporation), on investigating the nature of cometary dust using BASS. They have recently combined infrared spectral data on 20 comets obtained during the past few decades. In particular, they investigated how the strength of the silicate emission feature and the excess grain temperature (above that of a blackbody in equilibrium at the heliocentric distance of the comet) are related to orbital parameters of the comets. They have confirmed that in most of the dynamically new and long-period comets these two parameters are well-correlated, but find that the short-period comets seem to deviate from this relationship. The short-period comets have systematically weaker silicate band strengths, while still radiating at temperatures above those expected for a blackbody. The dynamically new comet C/2001 X5 Kudo-Fujikawa was found to possess an extremely weak silicate band, among the weak-

est yet detected for that class of object. Despite the weakness of the emission band, features due to crystalline silicate material were easily detected. The shape of the band after removal of the underlying continuum was also found to be similar to that of other comets with intrinsically stronger features, suggesting that the source and processing of the silicate material was the same in all of these objects.

Between 14 May and 21 June 2004, Sitko, Russell, J.L. Wilde and W.J. Carpenter (Univ. of Cincinnati) and S.M. Brafford (Univ. of Dayton) carried out a series of 3-13 μm spectral observations of the bright comet C/2001 Q4 (NEAT) using BASS on the 1.5 meter telescope of the Mount Lemmon Observing Facility. During the period of time covered by the observations, the comet diminished in brightness by a factor of about 7. The silicate emission band near 10 microns was observed to vary in intensity compared to the continuum, ranging from a ratio of 1.65 to 1.09. The overall grain temperature, determined by fitting the underlying continuum, also changed from night to night, but in all cases was in excess of the equilibrium temperature expected for blackbody grains at the heliocentric distance of the comet. Structure within the silicate band indicated the presence of a significant amount of crystalline dust. The continuum shortward of the silicate band was nearly a power-law in character.

2.3 Stellar Astrophysics

Hanson has recently completed a new spectroscopic atlas of hot massive stars to update the one she published in 1996. The new atlas includes over 3 dozen O and early-B stars, observed at high signal-to-noise (S/N $\sim$ 150) and resolution (R $\sim$ 9000) in the H and K near-infrared bands. Besides improving upon the 1996 atlas paper on massive stars, these high quality spectra allow direct fits of the stellar profiles, allowing for the first tests of new atmospheric models being developed with collaborator Joachim Puls (U. Munich, Germany) for quantitative analysis of hot massive stars in the near-infrared. The atlas will be published in 2005, and the model results will soon follow.

Sitko collaborated with a number of Aerospace Corporation personnel (D.K. Lynch, R.J. Rudy, R.W. Russell, S. Mazuk, C.C. Venturini, and W. Dimpfl) who undertook both near-IR (0.8-4.6 μm) and mid-IR (3-13.5 μm) spectra of the unusual star V838 Mon. This now-famous object has exhibited a plethora of unusual features during the course of its evolution. Among these are numerous molecular bands due to metal oxides, and a feature near 10 μm that is most easily interpreted as a silicate emission band with a self-absorbed core. The mass of the ejected material is estimated at 0.04 solar masses.

2.4 Personnel Changes

Dr. Matthew Kenworthy left the department in Summer 2003 to begin a position as an Instrument Scientist on the MMT Observatory, at the U. of Arizona. Melodie Fickenscher joined Hanson's group as a research assistant in July 2003 and in July 2004, she switched over to being a master's student in the department. Badra De Silva completed her master's thesis in August 2003. Graduate student, Yara Beshara, joined the astronomy group in Fall 2003.

PUBLICATIONS

The publication list includes all papers published or submitted between July 2003 and June 2004 by the staff.

Bergin, E., Calvet, N., **Sitko, M.L.**, Abgrall, H., D'Alessio, P., Herczeg, G.J., Roueff, E., Qi, C., Lynch, D.K., Russell, R.W., Brafford, S.M., and Perry, R.B. 2004, ''A New probe of the Planet-Forming Region in T Tauti Disks,'' ApJL, 614, L133-L136.

Cohen, D.H., **Hanson, M.M.**, Townsend, R.H.D., Bjorkman, K.S., Gagne, M. 2005, ''Diagnostics of Disks around Hot Stars,'' ASP Conf. Series, in press.

Hanson, M.M. 2003, ''A Study of Cyg OB2: Pointing the Way Towards Finding Our Galaxy's Super Star Clusters,'' ApJ, 597, 957

Kenworthy, M.A, and **Hanson, M.M.**, 2004, ''Minimizing Strong Telluric Absorption in Near Infra-red Stellar Spectra,'' PASP, 116, 97.

Lynch, D.K., Rudy, R.J., Russell, R.W., Mazuk, S., Venturini, C.C., Dimpfl, W., Bernstein, L.S., **Sitko, M.L.**, Fajardo-Acosta, S., Tokunaga, A., Knacke, R., Puetter, R.C., and Perry, R.B. 2004, ''0.8-13 μm Spectroscopy of V838 Monocerotis and A Model For Its Emission,'' ApJ, 607, 460- 473.

Polomski, E.F., Woodward, C.E., Telesco, C.M., Pina, R., Butner, H., Holmes, E., Lynch, D.K., Russell, R.W., **Sitko**, M.L. and Wooden, D.H. ''Dust Morphology and Composition in FU Orionis Stars,'' AJ, accepted.

Sitko, M.L., Lynch, D.K., Russell, R.W., and Hanner, M.S. 2004, ''3 - 14 Micron Spectroscopy of Comets C/2002 O4 (Hönig), C/2002 V1 (NEAT), C/2002 X5 (Kudo-Fujikawa), C/2002 Y1 (Juels-Holvorcem), 69P/Taylor, and the Relationships among Grain Temperature, Silicate Band Strength and Structure among Comet Families,'' ApJ, 612, 576-587.

M. Sitko
M. Hanson