ISO KEY PROJECT:

EXPLORING THE FULL RANGE OF QUASAR/AGN PROPERTIES

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Annual Report

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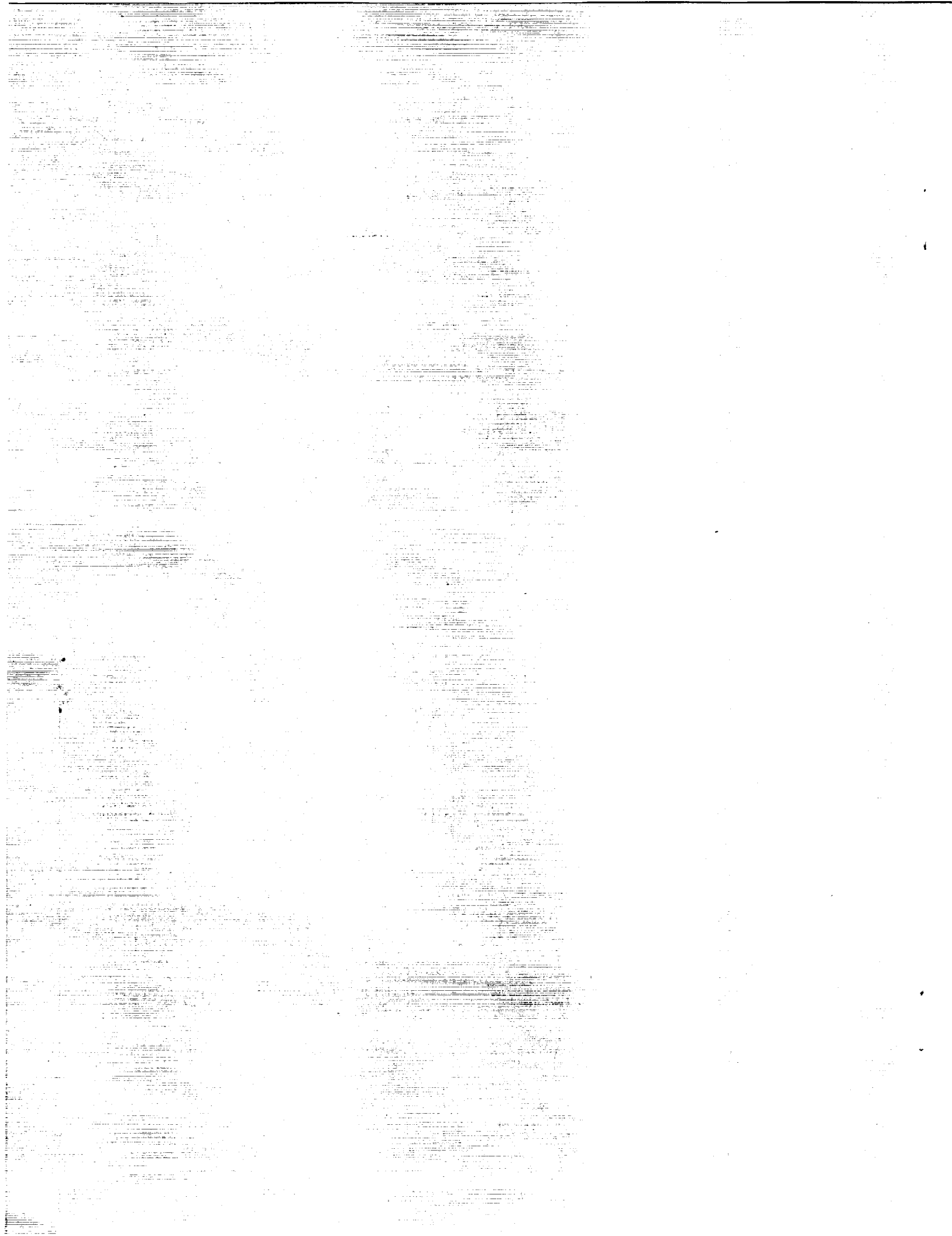

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1 TASK A — P.I.: B. Wilkes

Data Analysis

The PIA (PHOT Interactive Analysis) software was installed on the HEAD SUNs and updated a number of times during the year as upgrades became available. We have learned how to use this software and begun analyzing our data. We have concentrated on observations with long (>256sec) exposure times to avoid the most extreme detector responsivity drift problems which occur with a change in observed flux level - ie. as one begins to observe a new target.

There remain a significant number of problems with analyzing these data including:

- the default calibration source (FCS) observations early in the mission were too short and affected by strong detector responsivity drifts
- the calibration of the FCS sources is not yet well-understood, particularly for chopped observations (which includes most of ours)
- the detector responsivity drift is not well-understood and models are only now becoming available for fitting chopped data
- charged particle hits on the detector cause transient responsivity drifts which need to be corrected
- the "flat-field" calibration of the long-wavelength (array) detectors: C100, C200 leaves significant residual structure and so needs to be improved
- the vignetting correction, which affects detected flux levels in the array detectors, is not yet available
- the intra-filter calibrations are not yet available
- The background above 60 microns has a significant gradient which results in spurious positive and negative "detections" in chopped observations.

As a result of these various problems, data analysis has proceeded slowly and we still do not have fluxes which are known well enough to address our main scientific questions.

Drs. Belinda Wilkes and Kim McLeod attended the workshop "Taking ISO to the Limits" at VILSPA, Spain in February. Dr. Wilkes presented initial results on low and high redshift quasars and discussed the problems which still remain in analyzing the data. They then visited the ISOPHOT data center in Heidelberg, Germany to discuss these problems and possible solutions with the ISOPHOT team. This visit improved the situation for: removing transients, correcting for vignetting. We also put together a plan for subtracting the background in the C100 detector which will allow us to correct for the background gradient and the pixel-to-pixel variations in the detector. We discussed the possibility of using DIRBE and IRAS data to provide an independent calibration of the background flux from 12–100 microns. Dr. Kim McLeod visited IPAC in July to discuss these latter two possibilities and we are currently investigating them further.

ISO Observation Planning

The ISOPHOT team have developed new recommendations for observing faint sources with ISHPOHT which involve small rasters rather than chopping. This was finalized around Feb 1997 and following this we re-designed the observations for the remainder of our observing time. We had put our program on hold in September when it became clear that chopped observations had major problems. The revised program, which included re-observation at long wavelengths using rasters for a number of high-priority targets and re-specification of new observations of others, was released in April 1997.

The latest prediction for the satellite lifetime has extended its life until April 1998. Our project has been allocated a 15% increase in our observing time as a result of this life extension. We are currently working on setting priorities in order to determine which targets to include in this additional time. This will help to offset some of the targets lost due to the significant decrease in detector sensitivity over pre-flight predictions.

Conferences and talks

Dr. Wilkes presented an invited talk at the conference "Quasar Hosts" in Tenerife, Sept 1996 entitled "ISO Observations of Quasars and Quasar Hosts". She presented preliminary results from the ISO data in comparison with host galaxy templates generated by Dr. McLeod. She also presented colloquia at Wesleyan University and Space Telescope Science Institute on "The Infrared Continuum of Quasars" including preliminary ISO results.

Ground-based Observing

Analysis of the remainder of the JHK images of our full ISO sample has now been completed. Optical spectra have been partially reduced and the data organized. The flux calibration still needs to be completed. We submitted several proposals to the JCMT to observe the observed-frame mm spectral region just longward of the ISO energy bands in collaboration with David Hughes and James Dunlop at ROE. The first run on these sources has been completed but data reduction is not yet complete. We have yet to hear the results of the latest round of proposals.

Personnel

Dr. McLeod will complete her three-year term as postdoctoral fellow on the ISO project this summer. Dr. Eric Hooper of Steward Observatory has been hired as her replacement and will start work in September 1997.

2 TASK B — P.I.: J. McDowell

There was no activity on this effort during the first year.

3 TASK C — P.I.: J. Stauffer

As of the current date, we have only received about half of the observations that were granted to us for our program. We do not consider any of our analysis so far to be "final" since the software available to us is still not optimized to deal with the known problems with the detectors. However, we have some results.

We have reduced our ISO observations on 6 Sco-Cen stars at 25 and 60 microns, 6 IC2602 A stars at 60 microns, and 10 IC2602 G stars at 60 microns. These stars are also observed at 90 microns; those data are not yet reduced. All of these observations were done as "sparse maps" in "staring" mode, meaning a continuous integration on the star with a continuous observation on a nearby patch of sky, as opposed to chopping. A few "AOT P22" observations (i.e., in chopping mode) were made of some targets before we switched to "staring" mode; those data are also not yet reduced.

Our reduction involved matching rising or decaying exponential functions to the raw detector voltages in cases where the data stream appears to be affected badly by transients, spikes, etc. This is most often the case for observations at the start of the "sparse maps." We solved for a predicted asymptotic detector response as if for an integration time longer than the 128 sec available to us. The asymptotic solutions are not hard to find and appear sensible. We make use of this same technique to solve for the absolute calibration factor in measurements of the onboard calibration source which are also generally affected by seemingly exponential-decay "drifts."

Four of the Sco-Cen stars have significant (> 3 sigma) detections at 25 microns after sky subtraction, well in excess of expected photospheric fluxes. Our reductions yield uncertainties of about 1-sigma = 20 mJy in 128 sec on-target / 128 sec on-sky observations. The flux densities in the sky "staring" observations are about 10-30% higher than COBE observations at the same ecliptic latitude, longitude, and solar elongation angles as our observations would indicate. This may be due to a residual systematic calibration error.

Our 60-micron staring observations (also 128 sec on-target / 128 sec sky) are presently reduced using nearby sky observations for flat-fielding as well as background subtraction. Only one of the Sco-Cen stars is detected significantly (> 3 sigma) in these C100 9-pixel array frames, but when the 6 stars are coadded, there is a significant (6 sigma) peak in the center pixel of the array in the flattened and sky-subtracted data, and no significant deviation from average in any of the other 8 pixels. The sum of 6 Sco-Cen stars at 60 microns is 1.9 Jy (6 sigma). Note that the same 4 stars detected at 25 microns are found to have the most significant (although, below 3 sigma) flux densities in pixel 5 at 60 microns. The significance of the 60-micron measurements can perhaps be increased by re-reduction using, e.g., a master flat. The calibration used is from measurements of the internal source. However, the average flux density in the sky measurements at 60 microns is 2x that in COBE observations of the same positions, so our absolute calibration seems quite uncertain at 60 microns. It is likely that we will be able to eventually produce reliable dust color temperatures from the 25- and 60-micron measurements of the 6 Sco-Cen stars.

Our similar 60-micron measurements of the 6 IC2602 A stars also show an excess in the center pixel in the sum of flattened and sky-subtracted frames, in this case 0.6 Jy (3.5 sigma). We do not have 25-micron measurements of these stars and will not be able to obtain them as there was a detector problem during the first attempt in summer '96, and the objects are now out of visibility for the rest of the mission. However, the average luminosity at 60 microns of the A stars in IC 2602 appears to be lower than for the younger Sco-Cen stars.

There is no significant detection at 60 microns in the coaddition of the 10 IC2602 G stars observed and reduced in the same manner as the A stars; 1-sigma for the center pixel in the coadd is about 0.1 mJy for our present reductions. This sensitivity may be increased by further data reduction.

We have submitted a WIRE GO proposal in order to attempt to improve upon these results, though we also hope that better processing of the ISO data may allow us to place better constraints on the IR fluxes of our program objects.

We have not submitted any papers based on our ISO data as yet.

4 TASK D — P.I.: S. Willner

All observations for this program have now been obtained. The first third of the data set was observed on 1997 January 27 and the remainder on July 4. The January observations have been received here and look good, while the July observations have not yet been received.

The plan is to process all the data at one time, probably during a visit to IPAC in the fall. Analysis should be straightforward once the data are calibrated in physical units. All required comparison observations are in hand. The budget for this project remains unchanged.

5 TASK E — P.I.: J. Moran

Although water vapor is expected to be very abundant in galaxies, its transitions are impossible to observe fro the earth, except in the partially transparent band longward of 400μm. Water vapor has been found in the nuclei of about 15 galaxies, lying in thin rotating gaseous disks that surround massive (10^7 $M_\odot$) central black holes. Microwave emission from this water has led to substantial advances in our understanding of these galactic nuclei. However, unobserved water vapor may lie elsewhere in the nuclei or at different wavelengths. We will use the ISO satellite to observe water vapor lines at 6μm, 29μm, and 194μm.

The first part of our data was acquired by ISO in March 1997. The post-doctoral fellow we hired to analyze the data is currently working on its calibration. His appointment will continue into FY 1998, and the grant will be used to support his activities.

6 TASK F — P.I.: P. Myers

Our ISO program is to observe nine regions of low-mass star formation at mid-infrared wavelengths to define the positions of the protostars and their associated outflow nebulosity, for comparison with molecular line maps. The ISO measurements will be used to constrain the protostellar positions more accurately than is possible form the IRAS satellite, and will be used to identify circumstellar nebulosity associated with small-scale outflow motions. The initial first-year analysis of our ISO maps also indicates the presence of multiple sources where IRAS found only single sources. All of these features are needed to correctly interpret the kinematic molecular line maps we have made of these regions. Our grant funds will be used to support collaborative visits with colleagues, to travel to IPAC in Pasadena for imaging analysis, to travel to meetings (AAS meeting in Washington DC in January 1998 and Protostars and Planets IV meeting in Santa Barbara, CA in July 1998) to present results, to purchase an external hard drive to store our data, and to hire a student assistant for each of two summers to help with data and image analysis.

7 TASK G – P.I.: M. Ashby

At this time, we have received data from a substantial fraction of our proposed observations from ESTEC. We have photometry data (PHT-03 and PHT-40) in hand for 41 of our galaxies. We have been fortunate in that a large fraction, some 30 of 45, of our priority 3 targets have been observed. Observations of an additional 5 galaxies have also been completed and we expect a delivery of those data shortly. Another 13 observations are pending in the current ISO schedule. We have chosen not to use PHOT-S as originally proposed since its lower than expected detector sensitivity made it prohibitive in terms of observing time. We are focussing instead on the photometry data.

We have examined the majority of the data thus far delivered. We have clear detections of o our targets thus far in almost all our passbands. At this time, however, we cannot say that our in-hand data are completely reduced. We are still gaining experience with the reduction techniques, particularly with methods for carefully removing retransient signals from the data in a way that doesn't introduce unwanted systematic errors. But as we come to understand the calibration techniques (and the data reduction software provided by ESTEC continues to improve) we expect to resolve these issues. Our intention is to measure the mid-IR SEDs for all our sample galaxies. A plot is attached showing SEDs for some of our sample, with the caveat that the fluxes should be regarded as strictly preliminary.

We have not yet submitted any papers based on our ISO dataset.