

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 24 Jul 97	3. REPORT TYPE AND DATES COVERED Interim 17 May 96-14 Aug 97
4. TITLE AND SUBTITLE Two Extremely Red Galaxies		6. FUNDING NUMBERS NAG 5-3370 (G)	
5. AUTHORS Dr. Robert D. Joseph, Dr. Joseph Hora, Dr. Alan Stockton, Dr. Esther Hu, Dr. David Sanders			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Hawaii Institute for Astronomy 2680 Woodlawn Drive Honolulu, HI 96822		8. PERFORMING ORGANIZATION REPORT NUMBER F 97 216 F 591 B 733	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) NASA/Goddard Space Flight Center Greenbelt, MD 20771		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT DISSEMINATION STATEMENT 2 Approved for public release Distribution Unlimited		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) First annual report covering preliminary results of PI's participation in the Infrared Space observatory (ISO) mission.			
14. SUBJECT TERMS ISO, ISOPHOT, ISOCAM		15. NUMBER OF PAGES 4	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

NSN 7540-01-280-8600
89)

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STANDARD FORM 298 (Rev 2-
Prescribed by ANSI Z39.18



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22 July 1997

Dr. Harley A. Thronson
Code SR
NASA Headquarters
Washington, DC 20546

SUBJECT: Annual Progress Report, Grant NAG 5-3370

Dear Dr. Thronson,

Enclosed is the annual progress report for the subject ISO block grant entitled, "Two Extremely Red Galaxies," under the direction of Dr. Robert D. Joseph (Principal Investigator), Dr. Joseph Hora, Dr. Alan Stockton, Dr. Esther Hu and Dr. David Sanders (Co-Investigators). This report covers the period 17 May 96 through 14 August 97. Also attached for your reference is the second year budget.

If you have any questions, please contact Chris Kaukali, Administrative Officer, at 808-956-7562, or email, kaukali@uhifa.ifa.hawaii.edu. Thank you for your continued support.

Sincerely Yours,

Robert D. Joseph
Principal Investigator

RDJ:ck
Enclosure

xc: Dr. Donald K. West, GSFC
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Progress Report on University of Hawaii ISO Block Grant

1) The ISO Central Programme Normal Galaxy Survey

P.I.: R. D. Joseph

Joseph is the Principal Investigator on one of the major observational studies in the ISO Central Programme, the ISO Normal Galaxy Survey. (*N.B.* this ISO project is part of the European Guaranteed Time since Dr. Joseph is a Co-Investigator on the ISO mission.) This is a survey of an unbiased sample of spiral and lenticular galaxies selected from the Revised Shapley-Arnes Catalog. It is therefore optically-selected, with a brightness limit of blue magnitude = 12, and otherwise randomly chosen. The original sample included 150 galaxies, but this was reduced to 74 when the allocated observing time was expended because the ISO overheads encountered in flight were much larger than predicted.

During the period since the ISO grant has been in force Dr. Joseph has spent time on this project in the following ways.

a) In the autumn of '96 Dr. Joseph prepared and submitted six proposals in response to the Call for Proposals for Supplementary observing time on ISO, made possible by the extended lifetime of the mission. These proposals were to supplement the observations in the Guaranteed Time obtain data on a larger sample of galaxies, and thereby come closer to achieving a database the size of the sample originally proposed. Early in '97 the ISO Observing Time Allocation Committee awarded an additional 91,000 seconds of observing time for these proposals. Dr. Joseph then spent most of two months preparing the detailed data for this additional ISO observing time for another 70 galaxies, and entering it into the ISO Proposal Generation Software. The first week of this effort was spent at the ISO Proposal Data Entry Centre at ESTEC in the Netherlands, where the basic problems were solved, and then continued by remote login to the Data Entry Centre.

b) In February '97 Dr. Joseph attended a workshop on "Taking ISO to the Limits: Exploring the Faintest Sources in the Infrared." The underlying aim of this workshop was to get people together who are reducing data obtained by two of the ISO instruments, ISOPHOT and ISOCAM, to share problems and solutions. These are the two instruments used in the Normal Galaxy Survey, and the workshop highlighted some of the problems Joseph and others have encountered in reducing their ISOPHOT data in particular.

c) A dedicated ISOPHOT data reduction software package, the "PHOT Interactive Analysis" software (PIA) has been developed at the Max-Planck-Institut für Astronomie (MPIA) at Heidelberg, Germany. Dr. Joseph has spent considerable time learning to use this package, which is essential for data reduction and calibration. However major problems with the calibration data in PIA were not understood and corrected until Version 6 was announced in February '97. Because there has been so much difficulty in getting believable results from the ISOPHOT data, Dr. Joseph spent over a week at the ISOPHOT Data Centre at MPIA, to get the help and advice of the people most expert in ISOPHOT data reduction and calibration, as well as the very latest understanding of the ISOPHOT calibration issues. This was immensely helpful. Although there remain significant calibration issues with ISOPHOT, the situation is now vastly improved. Dr. Joseph has now completely reduced the photometric data at 60 μm , 100 μm , and 185 μm for all 74 galaxies so far observed using the latest version of the PIA software, Version 6.3. Comparison with IRAS photometry at 60 μm and 100 μm gives excellent agreement for galaxies which are unresolved by the ISOPHOT C100 detector array. He will begin work on reducing and calibrating the 10 μm images taken with ISOCAM for these 74 galaxies in the coming year.

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c) Comparison of the ISOCAM data with ground-based observations at optical and near-infrared wavelengths will be used to test the reliability of source identification and to identify extremely red sources seen in the LW2 filter but not at K-band.

3) Correlations between Far-Infrared Spectra and QSO Host Galaxy Morphology

P.I.: Alan Stockton

We have not yet begun reductions of our data, since all of our ISOPHOT observations have been taken with the chopper mode (before optimized procedures for taking observations of faint sources had been developed), and we wish to wait until the best approaches to reducing such data are known. The PI plans to visit IPAC this Fall to do the reduction. In the meantime, we are trying to ensure that our remaining observations are carried out in a way that will optimize our detections.

4) The Spatial Distribution of Cool Dust in Planetary Nebulae

P.I.: J. Hora

The computer hardware and software upgrades necessary for processing the ISO data have been purchased and installed. Some of the data in our program has been obtained by ISO, and recently it has been delivered to us in a useable format, although the calibration is not yet certified as correct. We are beginning to analyze the data, and await the delivery of the remainder of our data set.

5) Search for Primeval Galaxies and Studies of Extremely Red Galaxies in $z \geq 4$ Quasar Fields

P.I.: Esther Hu

This task supports a deep imaging search for high redshift galaxies around a $z=4.7$ quasar using ISOCAM and investigation of the far-IR spectral energy distribution (ISOCAM and ISOPHOT) of extremely red galaxies in a second $z=3.8$ quasar field. Preliminary analysis of ISO data on the red galaxy field puts limits on the far IR flux, and indicates that these galaxies are likely to represent a population of high-redshift ellipticals rather than luminous dust-reddened objects. This interpretation is supported by follow-up deep ground-based Keck imaging on this field, which has identified a number of other extremely red galaxies surrounding the ISO field, suggesting a clustered, high-redshift red population. In the upcoming year we will concentrate on the analysis of the faint population in these two fields as well as the detailed study of the red galaxies.

Publications

"Preliminary results of the ISOCAM deep survey for primeval galaxies," Taniguchi, Y., Kawara, K., Okuda, H., Matsumoto, T., Wakamatsu, K., Sato, Y., Cowie, L., Sanders, D. B., Joseph, R., Wynn-Williams, G., Chambers, K., Desert, F. X., Sofue, Y., & Matsuhara, H. 1997, in *Taking ISO to the Limits: Exploring the Faintest Sources in the Infrared*, eds. R.J. Laureijs, D. Levine (ESA Workshop Proceedings).

"Review of Workshop," Sanders, D. B. 1997, in *Taking ISO to the Limits: Exploring the Faintest Sources in the Infrared*, eds. R.J. Laureijs, D. Levine (ESA Workshop Proceedings).

"ISOCAM 7-micron deep survey of the Lockman Hole: A mid-infrared search for primeval galaxies," Taniguchi, Y., Cowie, L., Sato, Y., Sanders, D. B., Kawara, K., Joseph, R., Okuda, H., Matsumoto, T., Wynn-Williams, G., Matsumoto, T., Chambers, K., Wakamatsu, K., Desert, F. X., Sofue, Y., & Matsuhara, H. 1997, A&A, submitted.