INFRA-RED SPACE OBSERVATORY observations of the Pleiades Brown Dwarfs Teide 1 and Calar 3

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Abstract.

Teide 1 and Calar 3 are unique objects in being the first solitary Brown Dwarfs discovered. This point deserves stressing - they are not companions to other objects (in fact they are distant from any other objects reducing contamination) and have been proved to be BD's by the Lithium test.

The European Space Agencys Infra-Red Space Observatory (Kessler et al 1996) (ISO[1]) Observing Time Allocation Committee accepted a proposal to observe one of these recently discovered Pleiades Brown Dwarfs with the camera onboard ISO. The proposed IR observations will provide important inputs to models of Brown Dwarf atmospheres.

This paper describes the rationale behind the observations and the instrumental approach chosen.

1. Introduction

Brown Dwarfs ('all bodies that form in a stellar fashion, but with insufficient mass to burn light hydrogen' - Stevenson, 1991) have been described as one of the Holy Grails of astronomy. Their mass, less than $\approx$ 0.08 Solar masses, is insufficient to enable them to ignite and burn hydrogen. They are postulated to exist in large numbers and could make up a sizeable fraction of the missing mass of galaxies.

Despite major searches no such objects had been detected, and all prior claims turned out to be wrong (see Stevenson 1991 and Jameson 1995). The best candidates seemed to be about half a dozen extremely cool dwarfs with spectral types M9 or later (Kirkpatrick et al 1995). While their mass-luminosity and mass-spectral-type relationship shows they are indeed close to the substellar limit, uncertainties in their ages, metal contents, and effective temperatures prevented an unambiguous assignment to substellar or stellar categories.

Given that field M dwarfs are probably older than 1000 Myr, they are likely to be stars rather than substellar objects (see Baraffe & Chabrier, 1996; Zapatero-Osorio, Rebolo & Martin, 1997).

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2. Pleiades Brown Dwarfs

Recently several Brown Dwarf candidates and possible planetary companions to stars have been discovered. Most of these are not detectable by ISO, being either faint companions of or near to bright stars.

However, two Brown Dwarf candidates have been discovered in the Pleiades, Teide 1 (Rebolo et al 1995) and Calar 3 (Zapatero-Osorio et al 1997). They were first considered Brown Dwarfs due to their extreme spectral type and luminosity. Later spectroscopic observations (Rebolo et al. 1996) indicated the presence of Lithium in these objects. This proves they are Brown Dwarfs - Lithium can only be destroyed in the nuclear processes in stars.

Teide 1 and Calar 3 are therefore definite Brown Dwarfs. What is also important is that they appear to be independent objects that formed by themselves. As such they are currently unique objects - the first two Brown Dwarfs from a potentially large population that could provide a solution to the missing mass problem. Therefore it is vital to obtain as much data of these two unique objects.

3. ISO

ISO will be used to obtain IR data in order to characterise them in the near-IR. As Stevenson (1991) pointed out in his review, knowledge of a BD atmosphere is needed as the basis of interpreting IR observations. Conversely, since these are the first two Brown Dwarfs known, IR observations will help in the production of Brown Dwarf model atmospheres.

As an example, if the opacity of species with strong lines is dominant, as suspected, then there can be deviations from the blackbody predictions for some IR windows. Dust in the atmosphere, however, can give a more 'blackbody' spectrum.

We therefore wish to determine the near-IR fluxes of these objects. The answer to this question is needed to help in the production of model atmospheres for these objects and help determine the amount of dust in them.

4. Expected fluxes and Planned Observations

The table below gives the observed J, H and K magnitudes of the two target objects. Extrapolating to the Infra-Red gives fluxes well below 1 Jansky and we therefore do not expect either the spectrometers (SWS and LWS) or the photometer (ISOPHOT) will be able to detect these objects. Only the camera, ISOCAM, can get down to these faint levels.

We therefore intend to observe using the Long Wave camera (the more sensitive) of ISOCAM. The flux expected through the LW1 (4 - 5 micron), LW2 (5 - 8.5 micron) and LW10 (8-15 micron) filters was estimated assuming a blackbody fit to the observations and is expected to be in the range 100 microJanskies to 1 milliJanskies.

How will we detect such faint targets?

The performance of CAM in flight is such that we can reach fluxes of the order of 100 microJanskies by rastering, i.e. making several sets of exposures

Table 1. Observed magnitudes from Pleiades Brown Dwarfs

Object	J 1.25	H 1.65	K 2.2
Teide 1	16.37	15.55	15.11
Calar 3	16.29	15.45	14.94

with the position of the object on the CAM array different for each set. LW1 and LW2 observations are possible on objects as faint as 100 microJanskies, but not LW10.

An example instrumental setting for the Teide 1 observation is:

- 6 arcsec pixel field-of-view
- 8*8 microscan
- stepping by 18 arcsec (3 pixels)
- 5 second integration per point
- 20 exposures per set

Total time per object = 3.9 hours

Both objects are visible from the end of July to the middle of September 1997.

References

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