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A quarter century of infrared observations of comets with BASS

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Abstract

The Aerospace Corporation's Broadband Array Spectrograph System (BASS) is a mid-IR instrument covering the 3-13.5 μm wavelength region at a spectral resolution of R~30-125. Between 1990 and the spring of 2013, BASS has observed over 20 comets, providing a unique data set from which to study the relationships between cometary grain characteristics and other properties, such as dynamical groups. Work is underway to collect and analyze this data set, some of which has never been published outside of conference proceedings and IAU Circulars, to provide a basis for mid-IR taxonomy of comets, including current (C/ISON) and future comets.

1. Introduction

Infrared spectrophotometry of comets provides information on the mineralogy, presence of crystalline material, and differences among dynamical groups [1], [2]. The presence of crystalline silicates was one of the great surprises of these studies, as these comets are believed to have remained at temperatures below 100 K for their entire history. This material likely requires that it be annealed or directly condensed in the hot inner proto-solar nebula and be transported outward by radiation pressure, entrainment in jets & winds, etc.

In the past 15 years, tremendous gains have been made with the advent of IR space observatories such as ISO and Spitzer, which can cover wavelengths inaccessible from the ground. Despite this, most of the IR spectra we have on comets were obtained with ground-based telescopes, and this is likely to be true in the near future. For this reason, large-scale surveys of comets with uniform spectral sampling and data processing will provide a valuable sample for study.

2. BASS

BASS [3] uses a cold beam splitter to separate the light into two separate wavelength regimes. The short wavelength beam includes light from 2.9 to 6 μm, while the long-wavelength beam covers 6–13.5 μm. Each beam is dispersed onto a 58 element blocked impurity band (BIB) linear array, thus allowing for simultaneous coverage of the spectrum from 2.9 to 13.5 μm. The spectral resolution $R = \lambda/\Delta\lambda$ is wavelength dependent, ranging from about 30 to 125 over each of the two wavelength regions. The entrance aperture of the instrument is a fixed circular hole 1 mm in diameter. At NASA's Infrared Telescope Facility (where many BASS observations of comets have been made) this corresponded to an effective beam size of ~3 arcsec when it was first placed into operation, but improvements in the internal optics has increased this to ~4 arcsec. Comet observations began in 1990 with C/1990 K1 (Levy) (Lynch et al. 2002), and have continued to this day, with comets C/2011 L4 (PanSTARRS) and C/2012 F6 (Lemmon) observed in April 2013. Throughout this time a single standardized flux calibration was utilized.

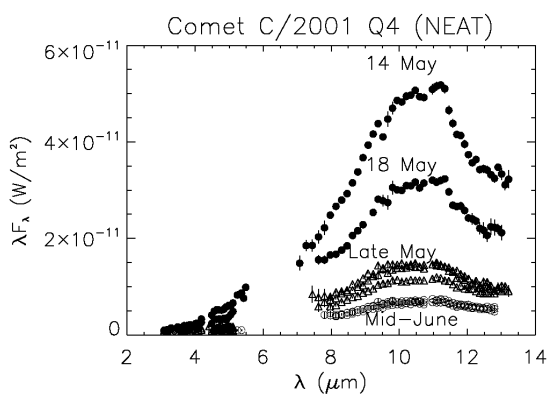

Figure 1 – BASS spectra of comet C/2001 Q4 (NEAT), observed on multiple epochs in 2004.

Table 1: Comets Observed with BASS

Comet	Reference
C/1990 K1 (Levy)	[4]
C/1993 A1 (Mueller)	[5]
C/1995 O1 (Hale-Bopp)	[6]
126P/IRAS	[6]
4P/Faye	[7]
24P/Schaumasse	[7]
19P/Borrelly	[7]
55P/Tempel-Tuttle	[8]
C/1999 T1 (McNaught-Hartley)	[9]
C/2002 O4 (Hönig)	[1]
C/2002 V1 (NEAT)	[1]
C/2002 X5 (Kudo-Fujikawa)	[1]
C/2002 Y1 (Juels-Holvocem)	[1]
69P/Taylor	[1]
C/2001 Q4 (NEAT)	[10]*
C/2002 T1 (LINEAR)	[11]*
C/2003 K4 (LINEAR)	[12]*
C/2004 Q2 (Machholz 2)	----
73P/Schwassmann-Wachmann 3	[13]*
C/2006 VZ_13 (LINEAR)	[14]
6P/D'Arrest	----
130P/Hartley 2	[15]
C/2009 O1 (Garradd)	[16]
C/2010 G2 (Hill)	----
C/2011 L4 (PanSTARRS)	[17]
C/2012 F6 (Lemmon)	[17]

* Only the first reference is listed

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