INTERSTELLAR CLOUDS AS SEEN IN THE ISOPHOT SERENDIPITY SURVEY

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ABSTRACT

A galactic minisurvey was carried out at 170μm analyzing ISOPHOT Serendipity Survey (ISOSS) data of the Cepheus, Chamaeleon, and Rho Oph molecular cloud complexes. Colour temperatures of 170μm extended and point-like sources were derived using ISOSS and IRAS 100μm data covering first time the 10K< $T_{\rm dust}$ < 20K temperature range in a high resolution large area survey. A number of cold clouds, and very cold cloud cores were found in association with optical nebulosities and molecular clouds.

Key words: ISOPHOT; Serendipity; ISM: cold dust; ISM: individual (Chamaeleon), (Cepheus Flare), (Rho Oph)

1. INTRODUCTION

The main task of the present galactic serendipity minisurvey was locating and identifying cold clouds, and very cold cloud cores.

The knowledge of the distribution of cold interstellar matter in galaxies is important for the understanding of the overall dynamics or the star forming processes. While IRAS discovered the FIR cirrus, COBE proved the presence of cold dust in the Milky Way (see eg. Lagache et al. 1998), the distribution of the latter component was first surveyed with high enough angular resolution by ISOPHOT measurements. Indications for even colder dust clouds were found already on the basis of IRAS 60/100μm by Laureijs (1991), while finally a detection of ≈ 13K grain temperatures was possible with ISO (see eg. Lehtinen et al. 1998).

Besides identifying galaxies (see Stickel et al. these proceedings) the ISOPHOT Serendipity Survey (ISOSS) allowed us to observe galactic interstellar clouds containing cool (≈ 17K) dust in cirrus, and cold (< 15K) dust in dark clouds with a resolution of 2 arcminutes. By measuring at 170μm ISOSS can reveal colder regions than IRAS, and due to the high resolution the coldest cloud cores may be identified which were not resolved by the 40 arcmin DIRBE beam. Almost 15% of the sky was mapped in ISOSS covering most of the known molecular cloud complexes as shown in Figure 1. Thus the sample we may obtain is much larger than any of the previous FIR air-born (see, e.g., Keene, 1981), sub-mm range ground-based (see ,e.g., Launhardt et al. 1997), or balloon (see, e.g., Ristocelli et al. 1998) measurements.

ISOSS and IRAS data of three regions of altogether ≈ 75 deg^2 were analyzed. Our minisurvey included the Cepheus Flare, Rho Oph and Chamaeleon mid/high galactic latitude molecular complexes. These selected complexes are nearby star forming regions, located at distances of d(Cha) = 150pc, 120pc< d(Oph) < 160pc (Knude & Hog, 1998 using Hipparcos and Tycho Catalogues), and 200pc< d(Cep) < 450pc (Kun 1998). Thus the cloud structure of these large reservoirs of interstellar matter may be successfully resolved by the ISOPHOT Serendipity Survey.

The density distribution of the gas component towards the ISOSS identified cold, and very cold areas has already been surveyed using CO lines. Under-

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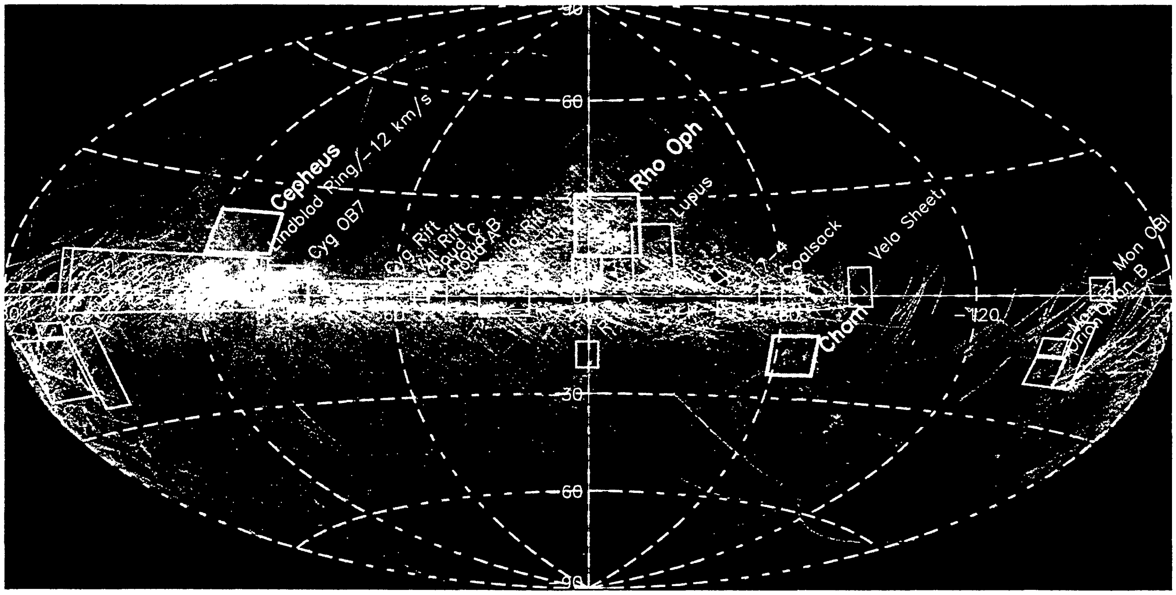

Figure 1. The 170μm sky brightness as seen by the ISOPHOT Serendipity Survey. Pixel size is 20'. Molecular complexes are marked with their boundaries, and names.

sampled ^{13}CO maps are available for all three regions from the Nagoya survey published by Yonekura et al. (1997), Nozawa et al (1991), and Mizuno et al. (1998), while the "CO webs" of Oph were mapped by Loren (1989) and a C^{18}O survey of Cha I was carried out by Haikala et al. (1998).

2. INPUT DATA AND DATA ANALYSIS

ISOPHOT Serendipity Survey (ISOSS) data was obtained with the C200 2x2 stressed GeGa pixel array (see Lemke et al., 1996) using the C_160 broad band filter. Details on the measuring mode and the standard signal derivation are given by Bogun et al. (1996), and Stickel et al. (these proceedings). The angular resolution perpendicularly to the slews is set by the Airy disk diameter ($d_{\rm Airy} = 2.2'$) of the C200 camera, and the "in-slew" resolution is not significantly larger than that since the 1/8 second on-the-fly integration depending on the slewing speed corresponds to an in-slew sampling interval of at maximum 1 arcminute. An indication of the in-slew PSF is the detection of pointlike sources such as UGC 10953 shown in Figure 6 of Stickel et al. (these proceedings).

The positional accuracy is always better than 2' according to Stickel et al. (these proceedings). The absolute photometric accuracy of the surface brightness values calculated with the ISOPHOT Interactive Analysis software PIA [1] version 7.1 or later was found to be 20% (Klaas et al. 1998). The dynamical range covered is 10MJy/sr< $I(170)$ <500MJy/sr.

IRAS ISSA data was extracted along the ISOSS slews (see Hotzel et al. these proceedings). The ISSA 100μm surface brightness values were multiplied by 1.3 according to the COBE DIRBE/ISSA transformation found by Wheelock et al. (1994) which was confirmed by our own comparative analysis of the 100μm DIRBE and ISSA data.

Data analysis: The ISOSS data was smoothed to the ≈ 4.7 arcmin spacial resolution of the ISSA 100μm images. The smoothed 170μm composite image of the Chamaeleon region is shown in Figure 1 of Hotzel et al. (these proceedings). The data then was investigated in two steps. At first cold clouds were identified by their positive 170μm excess defined as $I(170)_{exc} = I(170) - 3.5 * I(100)$. Assuming an emissivity proportional to ν^2 a ratio of $\frac{I(170)}{I(100)} = 3.5$ corresponds to ≈ 15.5K color temperature. That is colder than the average color temperature of cirrus clouds (see eg. Lagache et al. 1998). Laureijs et al. (1991) used a similar relation to identify cold, 60μm deficient regions by their IRAS 100μm excess.

In the second step very cold spots ($T_{dust} < 13$K) were searched among the ISOSS peaks (see more details in Hotzel et al. these proceedings).

3. RESULTS

Some of the findings are summarized for our test regions below. The size of the studied regions in Rho Oph, Chamaeleon, and Cepheus were ≈ 20 deg^2, ≈ 35 deg^2, and ≈ 140 deg^2 respectively. Detailed results of the ISOSS galactic minisurvey will be given elsewhere listing all coordinates, and physical parameters derived.

Rho Oph: Extended $I(170)_{exc}$ is absent in the Rho Oph field. This is the warmest of the 3 studied regions. Only 8 very cold spots were found, which may

[1] The ISOPHOT Interactive Analysis (PIA) is a joint development by the ESA Astrophysics division and the ISOPHOT Consortium. Contributing ISOPHOT Consortium institutes are DIAS, RAL, AIP, MPIK, and MPIA

account for only a small fraction of the $0.3 \times 10^5 M_\odot$ total mass. All the very cold spots are in association with Loren (1989) CO clouds. Loren (1989) found 86 ^{13}CO condensations there, ISOSS observed at least partly 65 (73%) of them. Color temperature was derived for 54 (83%) of the observed clouds. The clouds of the Rho Oph field are among the most active star forming sites in the nearby interstellar matter as shown by a comparison of the young star content of the Cha, Cra, Lup, Oph, and Tau clouds by Chen et al. (1998). The high energy density interstellar radiation field may result the observed low number of very cold spots.

Chamaeleon: Seven extended cold clouds showed $170\mu m$ excess in the $0.1 \times 10^5 M_\odot$ ISM in Chamaeleon. These are all located inside large ^{12}CO clouds of Dame et al. (1987). We found 18 very cold spots, all associated with ^{13}CO clouds of Mizuno et al. (1998), and with optical nebulosities. Those 4 which were already measured in $C^{18}O$ (1-0) have low gas kinetic temperatures of 7 ± 1K. See also Hotzel et al. (these proceedings).

Cepheus: The cold clouds form 3 large associations at the eastern, northern, and western boundaries of the $2 \times 10^5 M_\odot$ Cepheus Flare giant molecular cloud, and one towards its center. As many as 105 very cold spots appear there. They are mostly associated with the extended cold regions, and are clustered. Two of the very cold spots of the Cepheus region were detected as ^{13}CO condensations by our dedicated follow-up measurements with the IRAM-30m telescope (Tóth et al. 1998). Investigations of the dark cloud L1168 (Lynds, 1962) are reviewed in Figure 2, where ISOSS, and IRAS sky surface brightness, and location of one of the serendipity slews, is displayed, and the associated molecular cloud is represented by ^{13}CO (1-0) line intensity map. The distribution of $C^{18}O$(1-0) and (2-1) line intensities are similar. The ISOSS detected very cold spot at the centre of L1168 was found to be a dense cold cloud core. A ring shaped CO core was revealed.

4. CONCLUSION AND OUTLOOK

The ISOSS data combined with IRAS $100\mu m$ images is a useful tool detecting galactic clouds, and differentiate among them according to their temperature in the 10K< $T_{\rm dust}$ < 70K range. Dust colder than 17K was not traced by IRAS, and clouds containing such cold dust were mostly not resolved by COBE DIRBE. The method used is capable of finding dense cloud cores of low gas kinetic temperature, thus is an effective way to locate these objects. Our mm-wavelength spectroscopic followup in Cepheus, and the $C^{18}O$ measurements of Haikala et al. (1998) and Vilas-Boas et al. (1994) in Chamaeleon demonstrates, that the very cold spots are actually cold molecular cloud cores

The very cold spot search will be extended to the Orion, Taurus, Cygnus, and the Southern Coalsack complexes. Based on the result of our galactic minisurvey we expect to detect few hundred very cold cloud cores in the Milky Way. A series of followup measurements in mm and sub-mm wavelengths has been started in order to derive the physical properties of the gas in the very cold cores.

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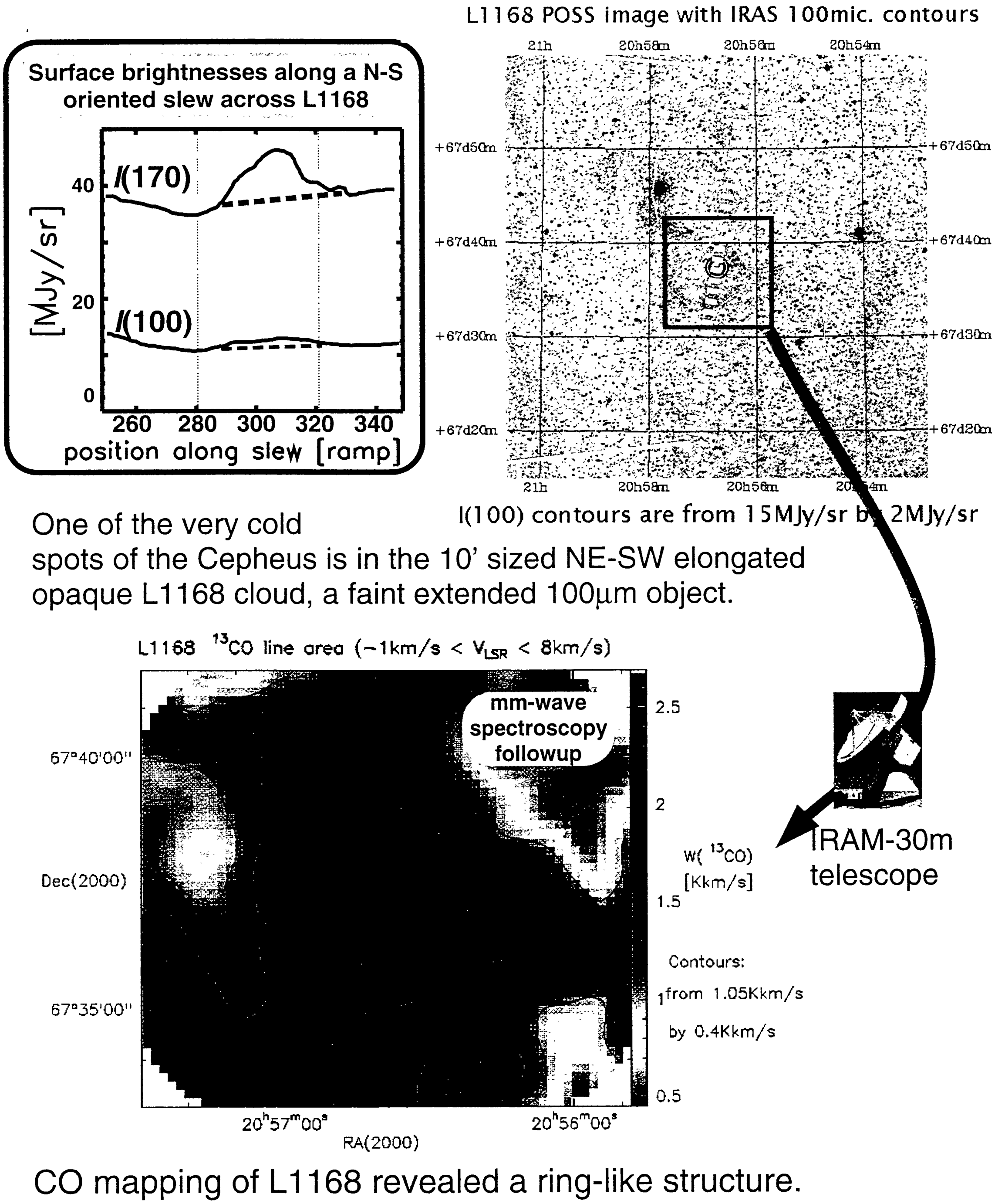

Figure 2. The L1168 dark cloud is one of the coldest spots of Cepheus. The ISOSS, and IRAS sky surface brightnesses are shown along a serendipity slew crossing L1168 in the top left. The cloud appears as a moderate extinction region on POSS (top right), where the 100μm ISSA contours are overlaid. It's IRAS 100μm excess over the background is small compared to nearby objects. The color map in the bottom shows the distribution of ^{13}CO (1-0) line intensity as measured with the IRAM-30m telescope by Tóth, Lisenfeld et al. (1998).