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A double core in the Auriga-California Molecular Cloud

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Abstract. Planck cold clump G163.82-8.44 is part of the Auriga-California Molecular Cloud. It was observed with Herschel PACS and SPIRE instruments as part of the Herschel open time key programme Galactic Cold Cores. Follow-up ground-based molecular line observation of NH_3 was performed to the densest part of the filament with the Effelsberg-100m telescope. We detected two different velocity components with a separation of 0.5 km/s. We performed radiative transfer modeling with two 3-dimensional spheres to characterise the temperature and density of the dense cores. We have found that the temperatures of the two cores are almost the same, 10.8 K and 11.1 K and their mass and size ratios are 1:10 and 1:5, respectively.

Keywords. radiative transfer, molecular data, ISM: structure, stars: formation

1. Introduction

Far-infrared colours help us exploring the structures of the nearby cold interstellar matter: large shells seen as far-infrared loops (Könyves *et al.* 2007 using *IRAS* maps), molecular cloud complexes such as HCL2 and isolated clouds (see Tóth *et al.* 2004 and Tóth *et al.* 2002 respectively using ISOPHOT data). Large-scale surveys are needed to study cold, dense interstellar matter in the whole Galaxy. The *Planck* (Tauber *et al.* 2010) all-sky survey has provided us a perfect database to identify the coldest structures of the interstellar matter in the Galaxy. The follow-up observations of these Planck objects with the European Infrared Space Observatory *Herschel* gave a unique opportunity to study in great detail the density and temperature structure of these objects at high angular resolution. In the Herschel open time key programme Galactic cold cores project (Juvela *et al.* 2010, 2012) we mapped ∼390 cold Planck objects on ∼120 fields with the *Herschel* PACS and SPIRE instruments (100-500 μm). Detailed study of these Planck objects were performed based on the Herschel data to study the physical properties, column density structures, filaments of these regions (see e.g. Montillaud *et al.* 2015, Rivera-Ingraham *et al.* 2016, 2017, Juvela *et al.* 2018).

One of our fields is G163.82-8.44 in the Auriga-California Molecular Cloud, it contains more than 30 Planck cold clumps (Planck Collaboration *et al.* 2011) found in large groups similarly to other fields in our sample, see e.g. Tóth *et al.* (2017). G163.82-8.44 is one of the longest and most striking filaments in the sample. Very clear striations are apparent in the Herschel images. It is located at a distance of 450 pc (Montillaud *et al.* 2015). We used the column density maps based on *Herschel* SPIRE data calculated by Juvela *et al.* (2012) to identify dense cores on the field and select the densest ones for molecular line follow-up observations.

2. Ammonia observation and radiative transfer modeling

We observed the NH_3 (1,1) and (2,2) inversion transition lines in the densest region with $N(H_2)>2\times10^{22}\,cm^{-2}$ in G163.82-8.44 with the Effelsberg 100-m telescope. The total on-source integration time was ∼4 hours. We used the 13 mm primary receiver of the telescope with frequency switch mode. The half-power beamwidth at this frequency is 40", 0.085 pc at the distance of 450 pc. Data were reduced with the Gildas package. See more details of the observations and data reduction in the description of the NH_3 survey by Tóth *et al.* (in prep). The observations revealed two velocity components with a separation of 0.5 km/s. Based on the ammonia observations, the two dense cores have kinetic temperatures, effective radii and volume densities of 8.7 K, 10.1 K; 0.071 pc, 0.123 pc; $7.18\times10^3\,cm^{-3}$, $9.59\times10^3\,cm^{-3}$, respectively. The estimated masses give a mass ratio of 7:1.

We used a non-LTE Monte-Carlo radiative transfer simulation (cppsimu, Juvela 1997) for the radiative transfer modeling of NH_3 line emission to determine the physical properties of the dense cores based on the best signal-to-noise ratio spectra in the centre part of the cores. The system is described with two spherically symmetric density distributions with Plummer-like profile. We successfully reproduced the spectra in the centre part of the cores with the model. We have found that the temperatures of the two cores are almost the same, 10.8 K and 11.1 K and their mass and size ratios are 1:10 and 1:5, respectively. A detailed description of the model with using all observations will be presented in Zahorecz *et al.* (in prep).

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