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NIKA2 OBSERVATIONS AND 3D MODELING OF L1506C, A PRESTELLAR CORE IN THE MAKING

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Abstract. To study the early stages of star formation, it is essential to characterize the properties of the dense structures such as filaments and their embedded cores. In this study of L1506C, a prestellar core in the making embedded in a filament in the Taurus molecular cloud, we combined observations of dust emission (with a broad wavelength coverage from FIR to mm), dust extinction, and 3D radiative transfer modeling. We found evidence for grain growth towards the dense part and successfully modeled the core's emission. Emission and extinction maps both bring strong constraints on the cores, filament, and the dust properties, but it is difficult to fit them simultaneously. To make progress, we will extend the geometrical parameter space probe as well as the dust models used to improve the modeling.

Keywords: ISM: clouds, infrared: ISM, submillimeter: ISM, dust, extinction, stars: formation

1 Introduction

At the initial stage of star formation, dense and cold structures such as filaments and prestellar cores are studied with the observation of thermal dust emission. Consequently, the estimated core properties derived from these observations are strongly influenced by the assumed dust properties that need to be characterized thoroughly.

Our target L1506C is a fragment of the filament L1506 in the Taurus molecular cloud (D $\sim$ 140 pc). It is contracting with a low density $n_{\rm H2} \leq 5 \times 10^4$ cm^{-3}, in the process of forming a prestellar core (Pagani et al. 2010). Previous observations revealed a significant increase in dust opacity in the densest part compared to the surrounding diffuse filament, which was interpreted as a result of grain growth (Stepnik et al. 2003; Ysard et al. 2013). Our goal is to bring further constraints on both the structures and dust properties, with observations of dust emission covering a broad wavelength range, from the FIR to mm range, and using 3D modeling including radiative transfer.

2 Data, methodology and results

We used both *Herschel* FIR observations and new complementary mm observations with NIKA2. We used the `scanam_nika` software to combine these space-born and ground base data (Roussel 2013). The analysis of spectral energy distributions (SEDs) over the whole spectral range were performed with both modified black body (MBB) fits and the dust modeling software DustEM using THEMIS(2) dust models (Compiègne et al. 2011; Ysard et al. 2016, 2024). We also used WirCAM data in the *J, H, K* bands for extinction measurements. The data are then analyzed with 3D modeling using the radiative transfer code SOC (Juvela 2019).

We manually fitted two ellipses according to $N_{\rm H2} \geq 5 \times 10^{21}$ cm^{-2} (white middle contours on Fig. 1, left) and defined them as the left and right cores. We also defined an outer filament region with $N_{\rm H2} \leq 3 \times 10^{21}$ cm^{-2} (regions outside the black contour on Fig. 1, left). The SED of the filament and cores were fitted with MBB function ($I_\nu \propto \nu^\beta B_\nu(T)$, Fig. 1, right). The two cores have similar temperature $T \approx 11$ K and spectral index

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$\beta \approx 2$, with masses ($0.8 \pm 0.1\ M_\odot / 1.0 \pm 0.2\ M_\odot$) smaller than their virial mass ($1.5\ M_\odot / 1.7\ M_\odot$), indicating that the collapse has not yet started. The filament has higher T and lower β than the cores, showing that dust has different properties in these regions. β of the filament is close to the value of the diffuse interstellar medium (~ 1.51 at mm wavelengths, Planck Collaboration et al. 2014).

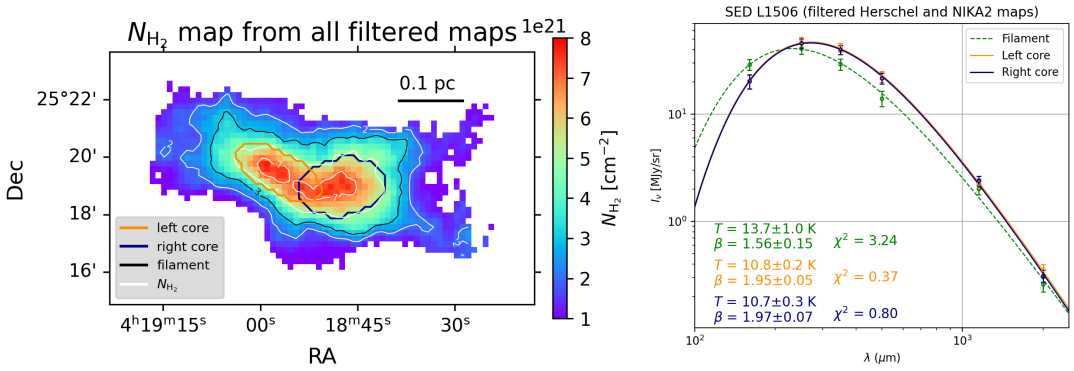

Fig. 1. Left: L1506C N_{H2} map from MBB fits at resolution of 36″ and definitions of the cores and filament (see text). N_{H2} is computed with the mass absorption coefficient κ from Beckwith et al. (1990). **Right:** SEDs and the fitted T and β values for the cores and the filament.

In the 3D modeling, the cloud density profile is modeled with a Plummer function with a flat inner region of $r_0 = 0.04$ pc and an asymptotic profile of r^{-2}. The cloud is modeled with diffuse-type dust in the outskirts and icy aggregates in the center with a transition threshold $n_0 = 3000$ H/cm^{-3}. The radiation field is the ISRF attenuated by an outer extinction $A_V = 1$ mag (Mathis et al. 1983). The modeled cloud shows good agreement with the maps (residuals $< 10\%$ in FIR and $10 - 25\%$ in mm). The modeled N_{H2} and n_{H2} both agree with estimations from molecular line observations ($N_{H2} < 2 \times 10^{22}$ cm^{-2} and $n_{H2} < 5 \times 10^4$ cm^{-3}, Pagani et al. 2010). However, A(J) is strongly overestimated by a factor up to 4.6 compared with WirCAM observations. We will further explore the parameter space and dust models to improve these results.

3 Conclusions

The combination of *Herschel* and NIKA2 data reveal the presence of two cores not yet in the prestellar stage, confirming that grain growth is already happening at this very early stage. Preliminary radiative transfer modeling shows that it is possible to fit the submm/mm data but that it is more difficult to fit simultaneously emission and extinction. We will explore the parameter space to improve the modeling results.

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