

Evidence for a Dense, Cold Screen towards IRAS 18507+0121

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Abstract

Self-absorbed profiles have been seen towards the core containing IRAS 18507+0121, a probable high-mass protostar, in the millimeter wave lines of HCO^+ , H^{13}CO^+ , CS, and C^{34}S . Especially, the $J = 1 \rightarrow 0$ line of H^{13}CO^+ is found to be stronger than that of HCO^+ . We have modeled this core in order to determine the physical conditions in it. To generate synthetic spectra from the model core, we used a multi-level, non-LTE radiative transfer code that employs a large-velocity-gradient approximation in order to estimate the level populations. It has been demonstrated that the line profiles can be explained by a collapsing hot core hidden behind a cold (~ 4 K) and dense ($3 \times 10^4 \text{ cm}^{-3}$) intervening, but comoving, *screen* or *envelope*. The model parameters adjusted to reproduce the observed profiles are (a) the temperature, density, and velocity fields in the model core and (b) the temperature, density, and linewidth in the screen. Comparing the observed profiles with the model spectra at both the on-center and one off-center positions, we have been able to reliably determine the physical conditions in the core.

Key words: Interstellar: clouds — Interstellar: molecules — Line formation — Nebulae: individual (IRAS 18507+0121)

1. Introduction

Dense cores in molecular clouds are the sites of star formation. The gravitational collapse of these cores, facilitated by ambi-polar diffusion, presumably leads to the formation of a disk. Accretion from the disk onto a central condensate is believed to lead to the formation of a star. The collapse of the core onto the disk/YSO system seems to continue well after the star starts its life. In a few cases, the collapse and molecular outflows are found to coexist. At some later stage the collapse seems to stop and, especially in the case of massive stars, an expansion powered by the central object possibly sets in. Thus, to understand better the complex process of star formation it is essential to probe the close vicinities of the star forming regions using tracers of high-density at high spatial resolution. A quantitative interpretation of such observations involves detailed modeling of the core and solving the radiative transfer in it using non-LTE methods.

Wood and Churchwell (1989) have formulated a two-color criterion to select embedded massive young stellar candidates from the IRAS Point Source Catalog. Bronfman et al. (1996) surveyed most of these objects using the $J = 2 \rightarrow 1$ transition of CS, a high-density tracer.

Among them, IRAS 18507+0121 has an interesting CS spectrum with a strong, wide, and asymmetric profile. Miralles et al. (1994) have mapped this source in radio continuum and NH_3 and searched for H_2O masers towards it. They found a weak (9 mJy) and compact ($\sim 2''$) continuum source with associated strong H_2O masers. A strong, elongated NH_3 core is found to be coincident with the continuum source. This source has been searched, but not detected in the radio continuum by both Bonn (Altenhoff et al. 1979) and 87 GB (Gregory, Condon 1991) surveys, implying that there is only a weak compact HII region with no extended radio emission. Judging by the radio and FIR emission, Miralles et al. (1994) found this source to be deficient in ionizing flux by more than an order of magnitude, whether it is placed at its nearer or farther kinematical distance. Thus, the present evidence indicates that it is a newly formed massive star which is embedded in a dense core with a possibly not-yet-developed compact HII region. Such objects are considered to be massive-star equivalents of the class-0 low-mass protostars, and probing their environment will help in understanding the process of massive star formation.

In this study, we modeled the core containing IRAS 18507+0121 using the spectra of high density tracers and derived the underlying physical conditions in the core. In section 2 we briefly describe the observations and salient features of the observed spectra. Section 3

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describes the features of the model core and the large-velocity-gradient (LVG) method used to compute the level populations. The features of the screen, the χ^2 measure used to choose the “best fit” and the physical picture of the core and the screen that results from this modeling are presented in section 4. In section 5 we present the results from applying a simple model proposed by Myers et al. (1995) to this core. We discuss the results from the LVG-based modeling in section 6. Finally, our conclusions are summarized in the last section.

2. Observations

Observations at 86–99 GHz were carried out during 1996 February–April using the 45m Nobeyama radio telescope in the position-switched mode. An acousto-optical spectrometer with 39 kHz ($\sim 0.13 \text{ km s}^{-1}$) resolution covering a total bandwidth of 40 MHz was used. An ambient temperature load was used for the calibration. During the observations the SSB T_{sys} ranged from 400 K to 600 K. First-order polynomials were fitted in order to estimate and remove the baselines. Most of the final spectra had an rms noise of ~ 0.1 K. The beam size of the telescope at the observing frequencies is $\sim 16''$ and the beam efficiency, η_{mb} , was determined to be 0.7. The pointing errors were less than $5''$ ($\lesssim 30\%$ of the beam size) and the relative calibration error was found, by comparing the line strengths obtained at the center over different days, to be less than 15%. The final spectra used for the analysis presented here were the averages of those observed on different days. Figure 1 shows the spectra observed at the center ($18^{\text{h}} 50^{\text{m}} 45^{\text{s}}.2, 01^{\circ} 21' 09''$) and off-center ($18^{\text{h}} 50^{\text{m}} 46^{\text{s}}.5, 01^{\circ} 20' 29''$) positions drawn by thick solid lines. Throughout this paper both the measured and synthetic spectral line strengths are in the antenna-temperature scale. The beam efficiency, η_{mb} , was taken into account in synthesizing the model spectra.

The following are the notable features of the spectra:

- 1 The peak antenna temperature of the $J = 1 \rightarrow 0$ line of HCO^+ is only 0.5 K while that of H^{13}CO^+ is 1 K. However, the peak antenna temperature of the $J = 2 \rightarrow 1$ line of the CS transition is 4 K, and that of C^{34}S is only 0.4 K. These indicate a selective absorption of HCO^+ relative to CS.
- 2 The profile of HCO^+ has a prominent dip in the blue-side close to the center. H^{13}CO^+ has its peak nearly coincident in velocity with this dip, indicating that it is a self-absorption feature. The CS profile also shows a dip at the same velocity. The weak C^{34}S spectrum also has its center closer to this dip. However, HCO^+ has a red-side peak that is stronger than the blue-side peak; it is the opposite in the case of CS.

- 3 The HCO^+ and CS profiles both have a FWHM of $\sim 5 \text{ km s}^{-1}$, with HCO^+ showing a more prominent red-side wing. However, both H^{13}CO^+ and C^{34}S are narrow with a FWHM of $\sim 2.5 \text{ km s}^{-1}$. The off-center spectra appear to be wider, possibly because of outflow activity. Since our present model does not include this component, hereafter we ignore this aspect.

- 4 Judging by the off-center HCO^+ spectra, the self-absorption dip is widely spread over a region of 3 to 4 beams. However, the self-absorption dip seen in CS is restricted to a few positions close to the center.

In the following, by modeling the cloud core, we attempt to explain the major features of the spectra observed at the on-center and off-center positions, and derive the physical conditions existing in the vicinity of IRAS 18507+0121. The model for the core that we consider here has two components: a hot core, and an intervening cold screen or envelope. Our initial attempts showed that the HCO^+ profile can not be explained solely by a core, and the second component is essential. Therefore, we describe here only our efforts using both of the components. Nearby dark clouds such as TMC 1 and L183 also show similar abnormal line ratios of HCO^+ and H^{13}CO^+ . Strong absorption by a fore-ground layer of cold-gas is thought to be responsible (Guélin et al. 1982).

3. The Warm Core and Spectral Synthesis

We assume that the core component is fully specified by a set of temperature, T , density, n , and velocity, V , fields. Since model cores considered here are spherically symmetric, the different fields are functions of only the radial distance, r , from the core center. We assume them to have the following power-law dependences on r :

$$T(r) = T_0 \times \left(\frac{r}{r_0}\right)^\alpha, \quad (1)$$

$$n(r) = n_0 \times \left(\frac{r}{r_0}\right)^\beta, \quad (2)$$

$$V(r) = V_0 \times \left(\frac{r}{r_0}\right)^\gamma, \quad (3)$$

where r_0 is the inner radius of the core. Thus, the model parameters are the three constants of proportionality, T_0 , n_0 , and V_0 , and the three power indices, α , β , and γ . An assumed set of values for them yields a particular realization of the model for which the line profiles for the specific transitions of the various species can be synthesized. These are then compared with the observed line profiles. We choose a model, specified by a set of values

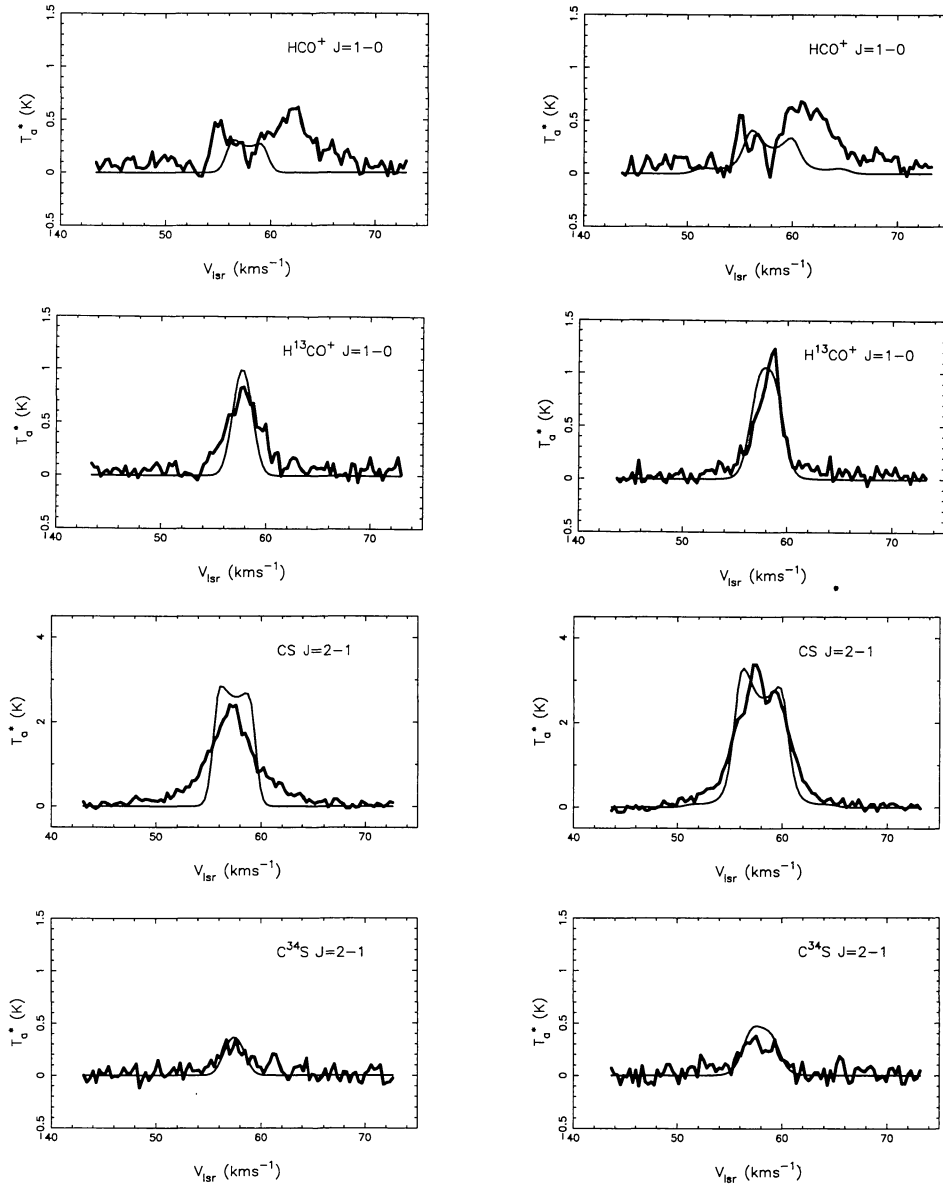


Fig. 1. The spectra obtained towards IRAS 18507+0121 in the $J = 1 \rightarrow 0$ transition of HCO^+ and H^{13}CO^+ and the $J = 2 \rightarrow 1$ transition of CS and C^{34}S . The left panels show the off-center spectra and the right ones show the center ones. The thick lines show the observed spectra and the thin ones are from the two-component model.

for the parameters, which reproduces the observed line profiles very closely as the “best” model. We discuss our results from such a “fitting” procedure to the lines observed towards IRAS 18507+0121 after describing how we synthesized the spectra from the model cloud core.

To synthesize a spectrum, the spectral radiation over the frequency range of interest needs to be integrated along the line of sight. This requires knowledge of level population distributions throughout the core (i.e., at all radii, in our case). The collisional and radiative transition rates determine the level populations at a point

through the coupled set of statistical equilibrium equations. Although the collisional rates are purely local, radiative rates are generally coupled to more distant places through the local photon density, which depends on the direction-averaged optical depth. However, by assuming the velocity gradient to be sufficiently large (and the density and temperature variations to be sufficiently small) such that physical conditions remain similar over the region in which an emitted photon can become re-absorbed, one can make the photon density to essentially depend only on the local optical depth and velocity gradient.

Then, one can solve the coupled system of equations locally at every point and obtain the level populations at various r . This method, popularly known as the LVG method (e.g., Goldreich, Kwan 1974) is simple and easily amenable to multi-level radiative transfer and is in wide use. Our code follows the approach outlined by Castor (1970). In practice, the level populations are computed at a finite number of discrete points (30 in our case with equal logarithmic steps from the inner to outer core radius) and are linearly interpolated for the rest. The LVG method is not strictly applicable to models with negative velocity gradients (i.e., $\gamma < 0$). This is because the lines of sight cross the surface of the constant radial velocity with respect to the observer at two points which are coupled through the radiation (see Deguchi, Fukui 1977). It is found, however, that the corrections due to this effect are only minor, especially for the velocity and density gradients obtained in the present case. Therefore, we applied the LVG method to cores with negative gradients while ignoring this *resonance* effect to generate the synthetic spectra to compare with the observed ones. We adopted a value of 3.8 kpc for the distance (Miralles et al. 1994). We used the $\text{HCO}^+\text{-H}_2$ and CS-H_2 collisional rate coefficients from Monteiro (1985) and Green and Chapman (1978), respectively. We used values of 2.3×10^{-9} and 4.0×10^{-9} for the abundances of HCO^+ , and CS, respectively, and isotopic ratios of 40 and 70 for $^{32}\text{S}/^{34}\text{S}$ and $^{12}\text{C}/^{13}\text{C}$, respectively. In the next section it will be clarified why we use a value for the CS abundance in the lower end of the range of values reported in the literature.

The basic procedure followed by our code is:

Assume for the initial guess a thermal level population corresponding to temperature T at that point .

Compute the source function and the photon escape probability assuming large velocity gradients and determine the angle averaged radiation field density (RFD).

Use RFD, transition probabilities, and collisional rate coefficients to compute new level populations.

Repeat the previous two steps until the measure of error becomes less than a limiting value set by the user. We use the square root of the sum (over all the levels) of the squares of the fractional corrections required in *both* the radiation field density and the level populations as the error measure.

We used 10^{-3} as the limiting value. We proceeded to synthesize the spectra in the following manner after obtaining the level populations:

- 1 Construct the source function and absorption coefficients at discrete radii.

- 2 Evolve the integral form of the radiative transfer equation along 100 rays parallel to the line of sight, spanning the projected cloud radius equally, using linearly interpolated values of the source function and the absorption coefficients at each position. The depth step size is adjusted so that the maximum change in the optical depth is ~ 0.01 . The line broadening due to turbulence is included by Gaussian-distributing the optical depth at every radius, centered at the local radial velocity.

4. The Cold and Dense Screen

Spectral emission thus synthesized is assumed to pass through a screen, characterised by its temperature, density, and turbulent velocity. The level populations were computed in the same manner as described above, except for keeping the velocity, density, and temperature constant throughout the screen. This is appropriate, since the screen is physically thin compared to the core.

In figure 2a we have plotted the variation in the ratio of the model optical depth of HCO^+ to that of CS against the screen temperature for various densities. The values of the abundances are the same as mentioned above. Similar plots are shown in figure 2b, except for different relative abundances, with the density kept at $3 \times 10^4 \text{ cm}^{-3}$. It is clear from these plots that the optical-depth ratio increases exponentially with decreasing temperature, especially below 5 K. This arises because we are observing the $J = 2 \rightarrow 1$ transition in the case of CS while the $1 \rightarrow 0$ transition in the case of HCO^+ . As the temperature decreases below the critical value, the ground level becomes more populated and the next level has a much smaller population. This means a smaller number of absorptions in the case of CS, but more in the case of HCO^+ , resulting in an exponential increase in their optical-depth ratios at low temperatures. Also, the lower the density the larger is the change in the ratio with temperature. However, when the density becomes lower than 10^4 cm^{-3} , the variation with temperature starts diminishing, since the level populations are determined more by cosmic background radiation rather than collisions.

The fact that we observed the absorption in HCO^+ , and not in CS, demands that the screen be cold at $\lesssim 4 \text{ K}$ with a density $\gtrsim 10^4 \text{ cm}^{-3}$, for only then it is possible for the screen to let through CS emission while absorbing much of HCO^+ emission at the same time. Admittedly, the density can not be specified more accurately with the current data. Nevertheless, it can not be much different from a value of $3 \times 10^4 \text{ cm}^{-3}$, as can be seen from figure 2. Moreover, it also matches the density found in the outermost parts of the model core, suggesting that the *screen* might actually be an envelope — an extension of the core that has remained still unaffected by the new-born star. The coincidence in the velocity of the core and the screen

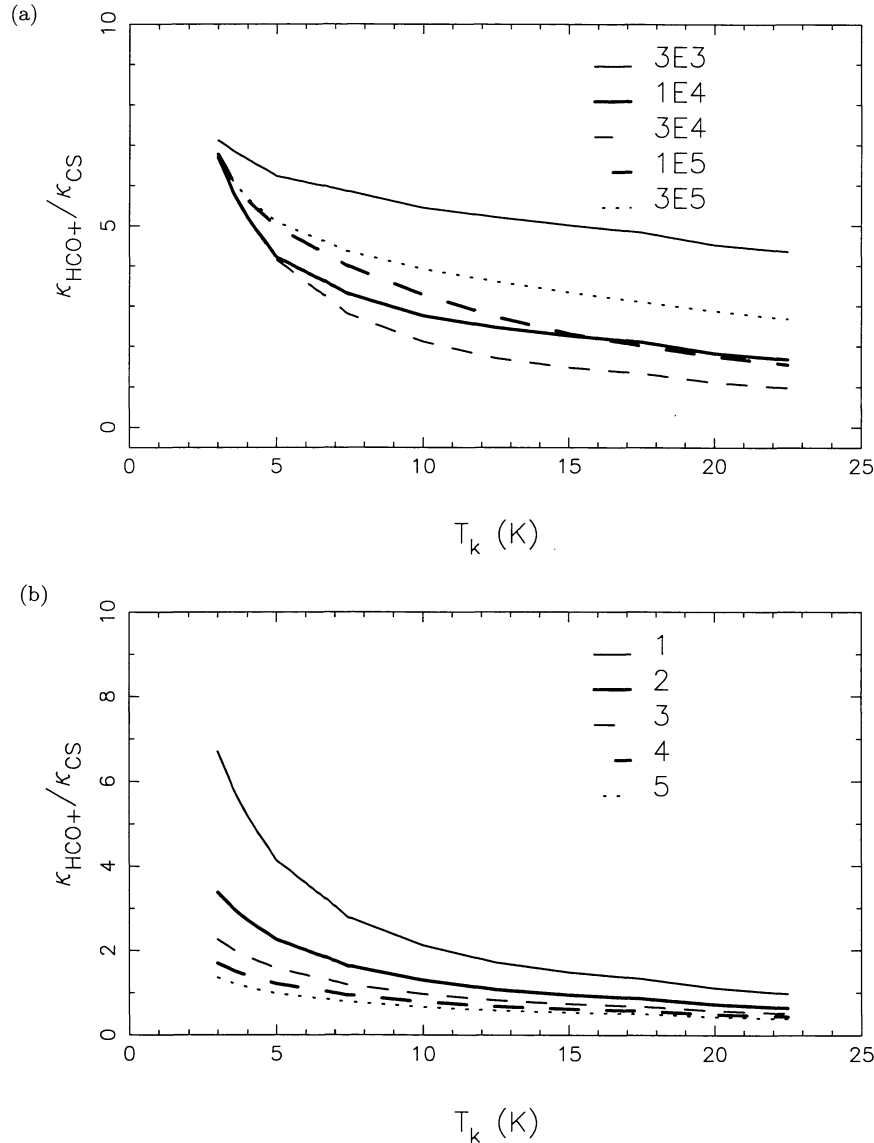


Fig. 2. The upper panel (a) shows the ratio of the optical depths of $\text{HCO}^+ J = 1 \rightarrow 0$ and $\text{CS } J = 2 \rightarrow 1$ transitions as a function of the gas kinetic temperature. Plots are shown for different molecular hydrogen number densities. The abundance ratio of HCO^+ to CS is taken to be 1. The lower panel (b) is similar to the upper panel, but for different abundance ratios of HCO^+ to CS while keeping the density fixed at $3 \times 10^4 \text{ cm}^{-3}$.

supports this idea further. Therefore, we have preferred a value of $3 \times 10^4 \text{ cm}^{-3}$ for the screen density. We also wish to note the following regarding the choice of the abundance values; since we need an optical-depth ratio of at least 3 to explain the observed HCO^+ and CS spectra, with the gas at a temperature of 4 K, it can be seen from figure 2b that the ratio of the abundance of CS to that of HCO^+ can not be more than 2 for the screen. Since the screen is likely to be the outer parts of the core, we have assumed the same abundance ratio for the core as well. For the abundance of HCO^+ we use the standard

value of 2.3×10^{-9} , and the above ratio consideration fixes the abundance of CS to be 4.0×10^{-9} . The model that “fits” the observed profiles well is chosen guided by a χ^2 measure, defined as

$$\chi^2 = \sum \left[\frac{T_{\text{obs}}(v) - T_{\text{mod}}(v)}{\sigma_{\text{obs}}} \right]^2 \quad (4)$$

Since the number of spectra to be fitted are many, and the weights for the χ^2 of the various “fits” are somewhat subjective, the chosen model is not strictly quantitatively based on the χ^2 measures. The following are

the characteristics of the model cloud core and the screen, found by the procedure outlined above, that reproduces the major features of the spectra observed towards IRAS 18507+0121:

- 1 The core exhibits a systematic infall motion. The velocity goes down as $r^{-0.6}$, with the inward velocity of 8 km s^{-1} at an inner radius of $4.5 \times 10^{16} \text{ cm}$. At an outer radius of $4.5 \times 10^{18} \text{ cm}$ it becomes comparable to a turbulent component of 1.0 km s^{-1} .
- 2 The density falls off as $r^{-0.9}$, its values at the inner and outer radii being $1.5 \times 10^6 \text{ cm}^{-3}$ and $2.4 \times 10^4 \text{ cm}^{-3}$, respectively.
- 3 The temperature is kept constant at 22 K throughout the core.
- 4 The observed HCO^+ and H^{13}CO^+ profiles require that the screen has a peak optical depth of 4 at the millimeter transition of HCO^+ and a line width of 3 km s^{-1} . This results in an optical depth of ~ 1 at the CS transition. Thus, *both* HCO^+ and CS spectral emission suffer attenuation by the screen, with the former suffering much more than the latter. Our trials show that the screen has the following characteristics: a temperature of 4 K, a density of $3 \times 10^5 \text{ cm}^{-3}$, a thickness of $5 \times 10^{16} \text{ cm}$ and a turbulent velocity of $\sim 3 \text{ km s}^{-1}$. For these values of the parameters its contribution to the line strength is very little, and it essentially acts as an absorber characterised by its optical depths at various transition frequencies.

The blue-side peak and self-absorption (within the core) feature seen in the CS spectrum is from the infall motion. This is not so well seen in the HCO^+ spectrum, since the absorption by the screen dominates. Also, the red-wing emission in HCO^+ , possibly arising from some outflow activity and not seen in CS, has modified the resultant spectrum to have a red-peak rather than a blue one!

5. Simple Model of Myers et al.

Recently, Myers et al. (1996) have suggested a simple, analytic modeling method to check if the observed spectra show any evidence for core infall motion. They modeled the core to be made of two uniform regions of equal temperature and velocity dispersion σ , whose density and velocity are attenuation-weighted averages over the front and rear halves of a centrally condensed, contracting cloud with $(n/n_0) = (r/r_0)^{-3/2}$ and $(V/V_0) = (r/r_0)^{-1/2}$. We used their approach and obtained the values of the four model parameters viz. τ_0 , T_k , V_{in} , and σ for both the core and the screen components. Figure 3

shows that the model fits to the observed on-center spectra. The values of the parameters for the core from the HCO^+ and H^{13}CO^+ spectra (using an optical depth ratio, resulting from the isotopic ratio, of 70) are: 30, 20 K, 0.12 km s^{-1} , and 1 km s^{-1} ; for the envelope they are: 3, 3.8 K, 0 km s^{-1} , and 2.5 km s^{-1} , respectively. The values of the parameters for the core from the CS and C^{34}S spectra (using an optical depth ratio, resulting from the isotopic ratio, of 40) are: 4, 28 K, 0.12 km s^{-1} , and 1 km s^{-1} ; for the envelope, they are: 0.4, 5.3 K, 0 km s^{-1} , and 2.5 km s^{-1} , respectively. The temperatures and dispersion velocities estimated from the Myers' model are in reasonable agreement with those from the LVG method. The envelope optical depths are also in reasonable agreement. However, in the Myers' model, the core optical depths for HCO^+ are overestimated relative to that of CS. This is presumably because of the simplicity of their model: molecules are treated to have just two levels, and no differences in the excitation of various molecules are taken into consideration. For this reason, the Myers' model does not take into account the variation in the ratio of the optical depths of HCO^+ and CS with the temperature mentioned above. Also, the infall velocities that it determines are too low compared to that suggested by the LVG method. Admittedly, the Myers' method is not applicable for situations where large velocity gradients exist. Nevertheless, it also supports the idea that there is a reasonably strong infall in the hidden core. Another point that we wish to note is that while the velocity profiles used here and those determined by the LVG method are similar, the density profiles are quite different. We could not fit the off-center spectra satisfactorily using the same density profile (with a power of -1.5) used in the analytic model. Since the analytic model can not fit the off-center spectra, we believe the density profile suggested by the LVG method is reliable. In conclusion, both the simple analytic model and the LVG model suggest that the core is collapsing and that there is a cold screen hiding it. Since the LVG model is more elaborate and better constrained by the off-center spectra as well, its results are more reliable, as discussed further below.

6. Discussion

Overall, our two-component model has been able to explain fairly well the spectra of *all* species, taken towards both the on-center and off-center positions. There are some discrepancies, especially in the off-center CS profiles and the HCO^+ wings. These may be due to the following reasons: (1) the wing emission, especially in HCO^+ , possibly arises from an outflow activity in this source, which has not been considered in the present model; evidence for the outflow, together with a detailed description of the observations and a comparison with the near-infrared

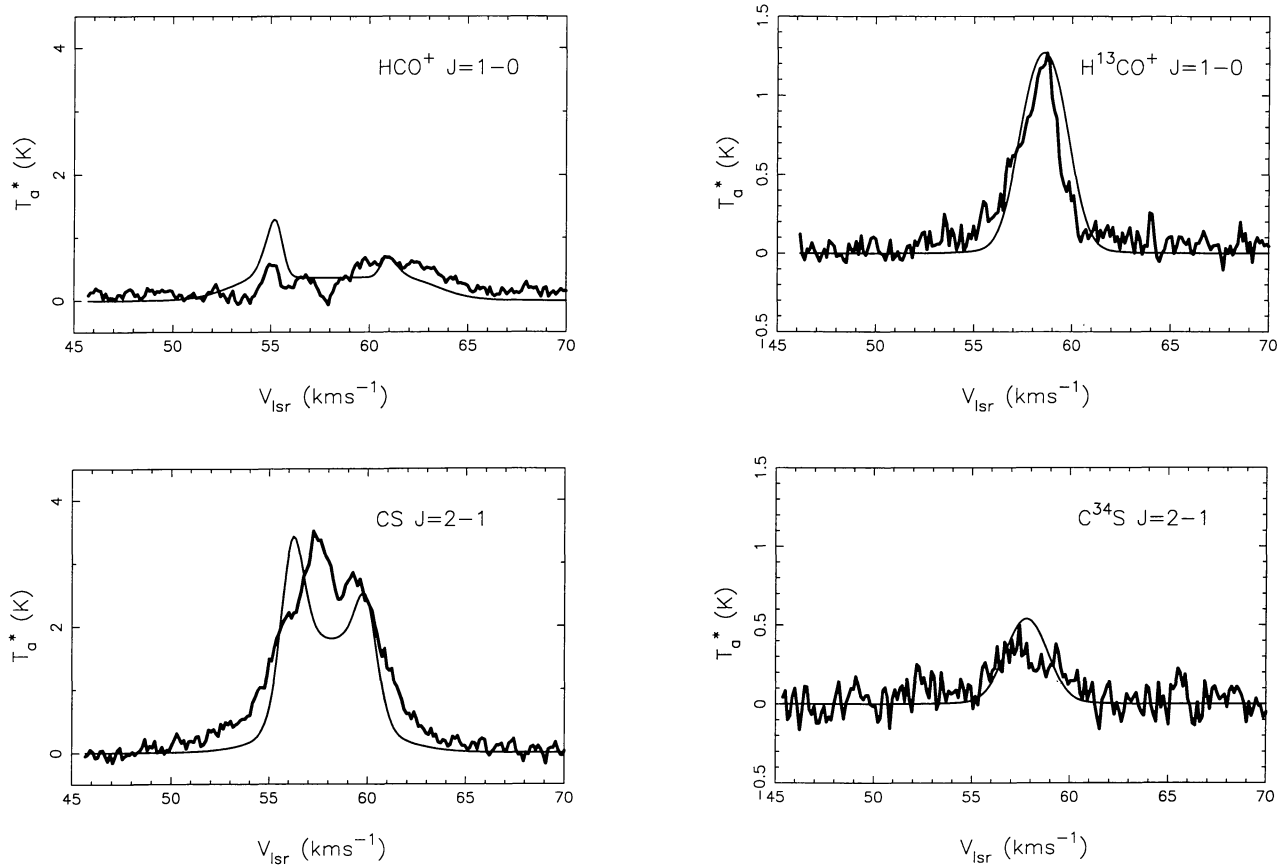


Fig. 3. Spectra towards the center and the fits obtained using the simple analytic model of Myers et al. (1996).

data will be presented elsewhere; (2) the LVG method has its limitations, and the density and velocity fields used here may only be first-order approximations to the actual fields in the core. Nevertheless, the overall “fitting” of the spectra and the agreement with the Myers’ model provide confidence in our analysis. Further, we wish to note that the temperature and the average density determined here are in good agreement with those found from NH_3 by Miralles et al. (1994). Therefore, we believe that ignoring the *resonance* effect has not significantly affected our calculations, and that the estimates of the physical conditions are reliable. From the model, we determined the core to have a mass of $800 M_\odot$, somewhat smaller than the estimate of Miralles et al. and the screen to have a mass of $200 M_\odot$. Our masses may be underestimated by a factor of 2, if the actual extent of the outer radius is 50% larger than the used here; densities are low in the outer parts of the core, they do not affect the line profiles significantly, and, therefore, estimating the outer extent more precisely is difficult. Our present value of the outer radius of the core agrees well with the size of the core estimated from the maps. The momentum in the infalling mass was found to be $1.13 \times 10^{41} \text{ g cm s}^{-1}$, and

the corresponding energy in the collapse is $9.4 \times 10^{45} \text{ erg}$. The collapse must be proceeding at least for 0.5 Myr, calculated by dividing the extent of a collapse of 0.5 pc by an average collapse velocity of $\sim 1 \text{ km s}^{-1}$. This source was not detected at 5 GHz either in the Bonn or 87 GB surveys. Miralles et al. in their VLA survey of this source found a lone, compact, spherical object of size $< 2''$ at both 6 cm and 2 cm. It has a flux density of 9 and 10 mJy at the two wavelengths, respectively. Following Margulis et al. (1989), the FIR luminosity is calculated from the IRAS data to be $1.4 \times 10^{38} \text{ erg s}^{-1}$ at its near distance of 3.8 kpc, corresponding to a star of spectral type B0.5. Even though the object is somewhat nearby (3.8 kpc), its compact size ($\lesssim 7600 \text{ AU}$) indicates that it is an isolated object. In this light, the weak continuum of 10 mJy, an order of magnitude less than expected, would suggest that this source is a high-mass equivalent of the class-0 low-mass protostars (Wilner et al. 1995).

This is further strengthened by the evidence of core collapse found here.

The detection of a cold, dense screen or envelope is also interesting. A likely possibility is that the screen is the outer remnant of a core that collapsed to form

IRAS 18507+0121, and, like the core, it is covered by a tenuous, warmer envelope that shields it from the interstellar UV and cosmic ray fields: the inner parts have become heated up by the star, while the outer parts of the core still remain cold. If this is true, it would suggest two things: (1) massive star formation is possibly preceded by the formation of a large, cold, dense condensate, not identifiable in emission; (2) IRAS 18507+0121 is a unique object which has been fortuitously caught in a transition phase which may not last very long. This would further support the extreme youth of IRAS 18507+0121. On the other hand, if the screen is completely outside the parent cloud of IRAS 18507+0121, following questions would arise: (1) why is its velocity so close to that of the cloud behind? (2) How does it survive the interstellar UV and cosmic-ray fields? (3) Why is its linewidth so large when it is so cold? The last question is possibly relevant to the earlier scenario as well.

In the analysis presented above, we have ignored the effects of carbon isotope fractionation. This, if present in the core, can reduce the abundance of HCO^+ relative to that of H^{13}CO^+ by a factor of 2 to 5, and therefore can reduce HCO^+ emission from the core (Guélin et al. 1982). However, if one assumes similar abundances in the screen as well, it would reduce the absorption by the screen more severely. Therefore, carbon fractionation, if present, may only make the screen colder and denser. It may be possible to make the intervening screen a little warmer if one invokes fractionation only in the core. However, this seems unlikely because fractionation is more at lower temperatures and, if at all, the screen is likely to be more fractionated than the core. Another trivial way to increase the temperature of the screen is to assume unusually high abundance for HCO^+ relative to CS in it. We have refrained from making any such ad hoc assumptions.

Before concluding, we wish to note that the density profile found here is significantly different from that which follows a simple spherical collapse or the inside-out collapse. This possibly needs to be confirmed by modeling the core using exact radiative transfer codes. If this is found to be true, it will imply that the collapse in the case of massive stars is of a kind that different from that found in the case of low-mass stars.

7. Conclusions

We have modeled the core containing IRAS 18507+0121, using the LVG method to determine the level populations. The synthetic spectra reproduce major features of the observed profiles fairly well. Based on the model we determined the physical properties of the core. It is found to have a radial distribution of density (cm^{-3}) of $1.5 \times 10^6 (r/r_0)^{-0.9}$ and a temperature of 22 K. The collapse velocity varies radially as $8 \text{ km s}^{-1} (r/r_0)^{-0.6}$. The core is estimated to have a mass of $800 M_\odot$ and an envelope of $200 M_\odot$. Various evidence including the deficit of ionised emission and the evidence for collapse, suggest that this object is quite young. The discovery of a cold, dense screen towards IRAS 18507+0121 further supports its extreme youth, and raises important questions regarding the precursors to massive star formation. If it is true that large regions become too cold and dense before the star forms, emission searches with dense tracers would be futile and absorption experiments would be necessary.

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