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Chemical evolution in a UV-illuminated magnetized pre-stellar core

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Abstract.

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We extend our previous studies of magnetized starless cores by including UV-irradiation effects into the coupled chemical and dynamical model with 1D treatment of a collapse, driven by the ambipolar diffusion. While the model without UV-radiation successfully reproduces column densities of key molecules, the theoretical line profiles hint at excessive abundances of CS and CO in the core envelope. The natural way to decrease these abundances is to include dissociating radiation. However, UV-radiation also leads to higher fractional ionization, thus, affecting the overall cloud dynamics.

We present results of the modeling for the dark core and for the core that is being illuminated by UV-radiation of various intensities. The irradiated model cores have longer evolutionary timescales and the infall speed that in the extreme case is about two times lower than in the dark model. The UV-irradiation also causes dissociation of the observed molecules like CO, CS, and others. Thus, the addition of UV-radiation tends to alleviate discrepancies in 1D models of magnetized collapsing cores that we described in Pavlyuchenkov *et al.* (2003). Initial line profile modeling confirms this conclusion, indicating, however, that the UV-flux is significantly attenuated (but still exists; see e.g. Young *et al.* 2004) in the vicinity of the L1554 core that we use as a template for our studies.

Allowing for the UV-irradiation also helps to reproduce observations of an isolated globule CB17 that has been investigated with the IRAM, the CSO and Effelsberg telescopes in lines of CO, $C^{18}O$, ^{13}CO, HCO^+, $H^{13}CO^+$, CS, and $C^{34}S$ as well as in dust thermal emission. We have simulated detailed spectral maps of this object with the chemical models having both stationary and non-stationary density radial profiles and found that some UV-illumination of CB17 is needed to reach an agreement between theoretical and observed line profiles. In Table 1 we show results of comparison of theoretical and observed $C^{34}S$(2–1) line intensities for the model with a static density profile. The χ^2 values indicate that the best agreement is reached in models with $G_0 = 0.1 - 1$ and evolutionary time $t = 0.7 - 1$ Myr.

In a non-static model, where density grows from the initially uniform state to the current non-uniform radial profile, the best fit evolutionary time increases up to 1.2 Myr. In Figure 1 we show theoretical and observed spectral maps of CB17 in the CS (2–1)

Table 1. Minimization criterion for the $C^{34}S(2–1)$ transition spectrum in CB17.

Model/time	0.3 Myr	0.5 Myr	0.7 Myr	1.0 Myr	2.0 Myr
$G_0 = 0$	110	80	57	36	23
$G_0 = 0.1$	108	49	24	22	30
$G_0 = 1$	90	34	20	25	30

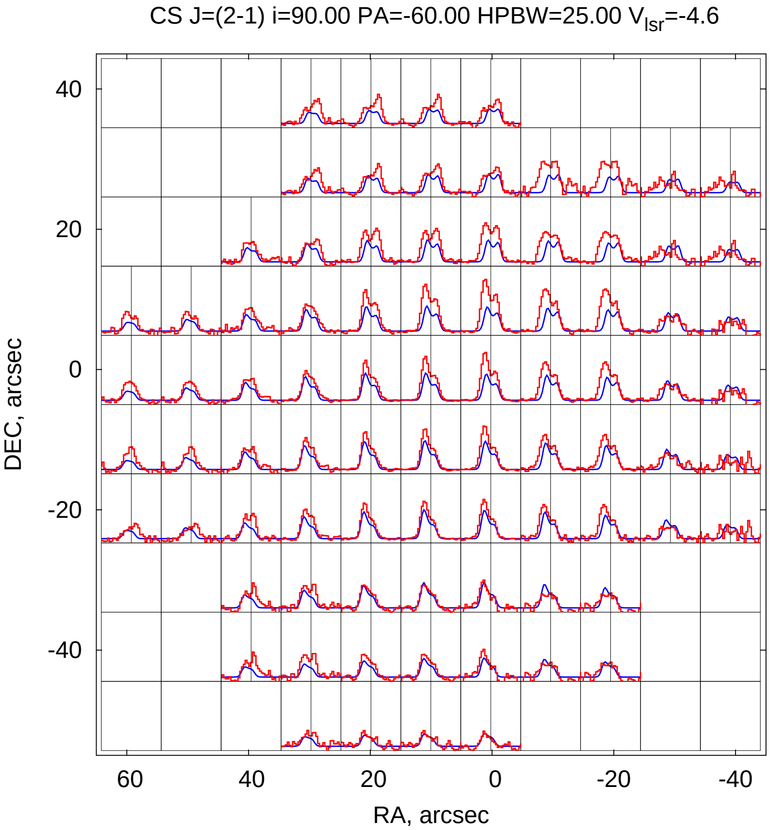

Figure 1. Theoretical (blue) and observed (red) spectral maps of CB17 in the CS (2–1) transition.

transition for the model age of 1.2 Myr. The globule is assumed to rotate differentially with the angular momentum of $2\,10^{55}$ g cm^2 s^{-1}. The maximum infall speed is 70 m s^{-1}.

In a wider context of studying various collapse regimes of UV-illuminated pre-stellar cores, we also present initial results for non-static chemical models that include monodeuterated species. We show, that by the end of the pre-stellar stage, model cores with different dynamical histories have different abundance ratios for many molecules, but similar fractinations.

References

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