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Time dependent chemistry in Planck cold clouds?

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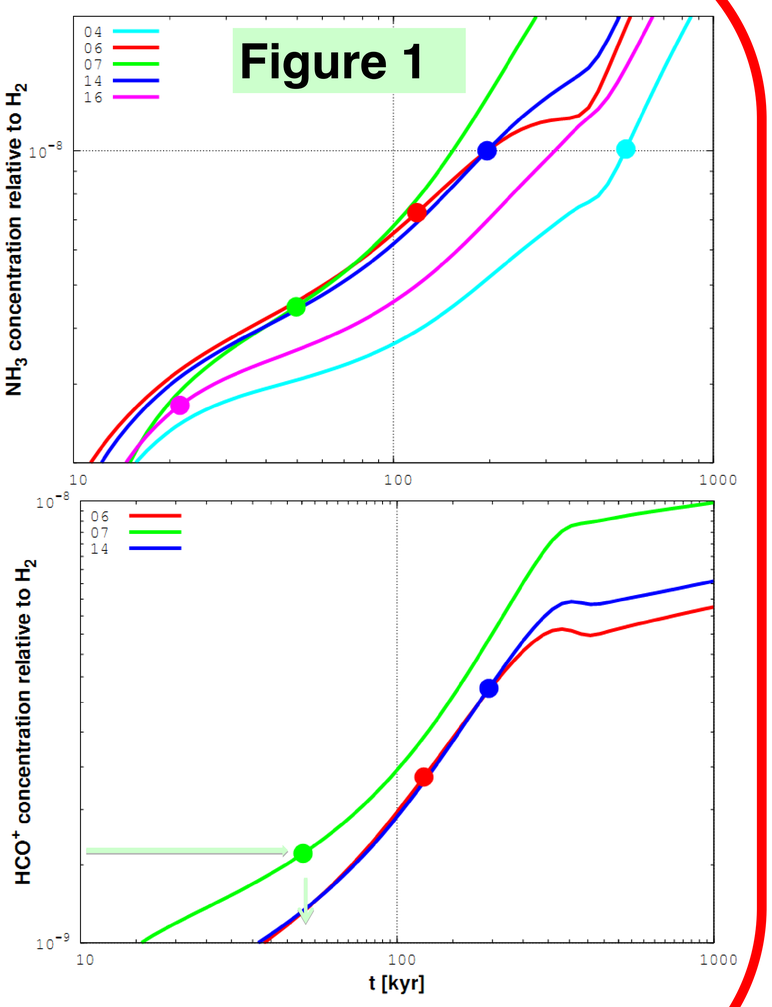
Abstract We present a set of time dependent chemical evolution models (based on the UMIST astrochemistry 2012 code, Woodall et al. 2007; McElroy et al. 2013) for a range of initial physical cloud parameters: 10 K < T < 20 K; 10^3 cm^{-3}< n(H_2) < $5\cdot10^4$ cm^{-3}; 1 < A_V < 10 and with estimated values of scaled interstellar ultraviolet radiation field. Our computation model included the full UMIST gas-phase reaction network for 467 species (Garrod et al. 2008, Graedel et al. 1982). We compare our chemical model results with the relative abundances of: CO, CH, OH, HCO^+, HCN, HNC, NH_3, N_2H^+ and H_2CO molecules. We find significant time dependent variations of the chemical ratios of: X(NH_3/H_2); X(HCO^+/H_2) and X(HCO^+/NH_3). We derive an ammonia age spread for the parts of TMC-1 (Taurus Molecular Cloud-1) that looks more complex than previous estimated showed. Age estimates based on X(NH_3/H_2); X(HCO^+/H_2) and X(HCO^+/NH_3) were compared in 3 selected positions, and were found to be very similar with 8,6% differences.

Modeling TMC-1

Time dependent variations of the abundance ratios of: X(NH_3/H_2); X(NHO^+/H_2); X(NHO^+/NH_3) were estimated with our chemical modeling. The input physical conditions were taken from Fehér et al. (2015, see also **poster: DHp.2.25**) at 16 positions along the TMC-1 dark cloud. As Figure 1 shows the ammonia and formyl ion abundances show a considerable increase in few hundred kyrs in the given range of density, extinction and temperature. The NH_3 and HCO^+ relative densities based on the observations of Fehér et al. (2015) and Onishi et al. (2002) help to find the "chemical age" of the given position in the evolution curves.

Figure 1



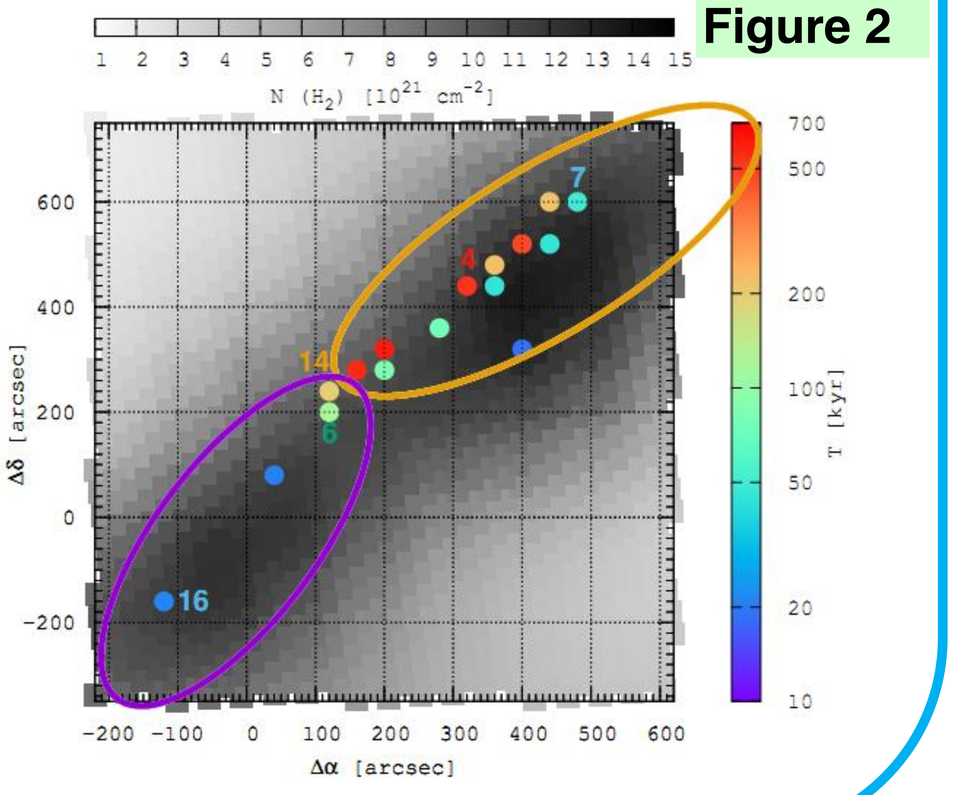
Results

Table 1 lists the 16 positions along the TMC-1 ridge with the derived ages. The observed N(H_2) column density is presented in Figure 2 (grey scale) with positions where "chemical ages" were estimated (shown with color circles, see also Figure 1, and Table 1). We note, that the northern part is not uniformly "chemically older", rather it consists of clumps with various "chemical ages". The average age of the orange (northern) ellipse are: 244 ±255 kyr; of the violet (southern) are 89 ± 66 kyr.

Table 1

Clump number	Age [kyr]
1	19
15	21
16	22
10	45
8	45
7	50
11	77
12	85
6	118
14	196
9	214
3	220
2	472
4	532
13	557
5	606

Figure 2



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