Protoplanetary disk masses from CO isotopologues line emission

A. Miotello[1,2], S. Bruderer[2], E. F. van Dishoeck[1,2] (A&A, Submitted)

(1) Leiden Observatory
(2) MPE Garching

miotello@strw.leidenuniv.nl

Why: One of the **key properties** for understanding how disks evolve to planetary systems is their gas+dust **mass.**

What: Model determinations of gas disk masses through a proper treatment of **CO isotopologues** compared with observations of optically thin ^{13}CO, $C^{18}O$, and $C^{17}O$ lines.

Conclusions:

The **disk mass** can be **underestimated** by up to **two orders of magnitudes** if isotope selective effects are not properly taken into account.

How it was done (NOISO):

The isotopologue ratios were taken to be constant at the elemental isotope values found in the local ISM.

How it is done (ISO):

Isotope-selective photodissociation is properly treated for the first time in a full thermo-chemical disk model. Isotopologues are considered as independent species.

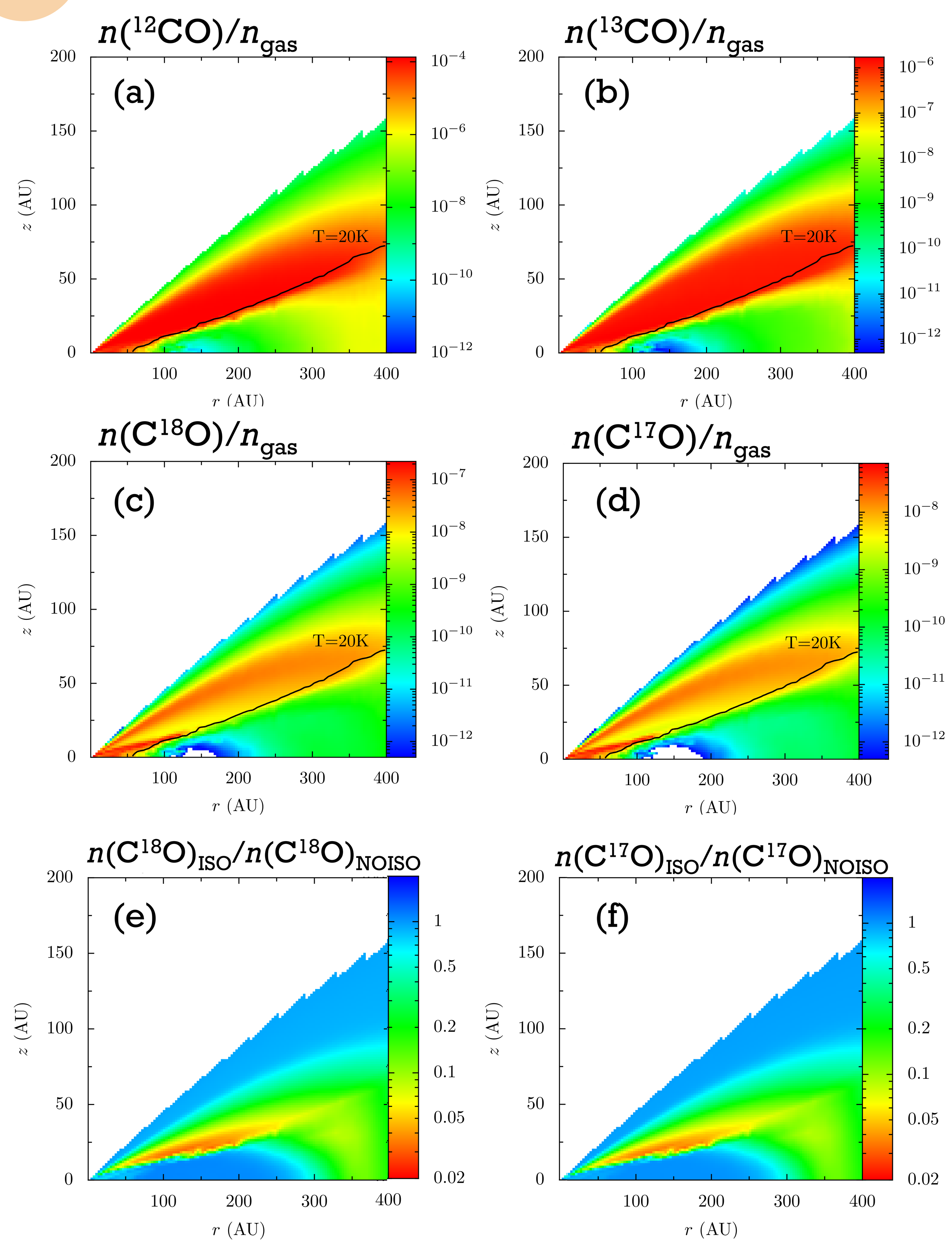
1. Parameters in the grid of models

Parameter	Range
Chemistry	
Chemical network	ISO / NOISO
Chemical age	1 Myr
Physical structure	
γ	1
ψ	0.1
h_c	0.1 rad
R_c	200 AU
R_{out}	400 AU
M_{gas}	$10^{-4}, 10^{-3}, 10^{-2}$ $M_\odot$
Gas-to-dust ratio	100
f_{large}	10^{-2}, 0.99
χ	1
Stellar spectrum	
T_{eff}	4000, 10000 K
L_{bol}	1, 10 $L_\odot$
L_X	10^{30} erg s^{-1}
Dust properties	
Dust	0.005-1 μm (small)
	1-1000 μm (large)

} dust (f_{large}, gas-to-dust ratio)
} star (T_{eff}, L_{bol})

The physical-chemical code DALI[1] is run

2. Abundances

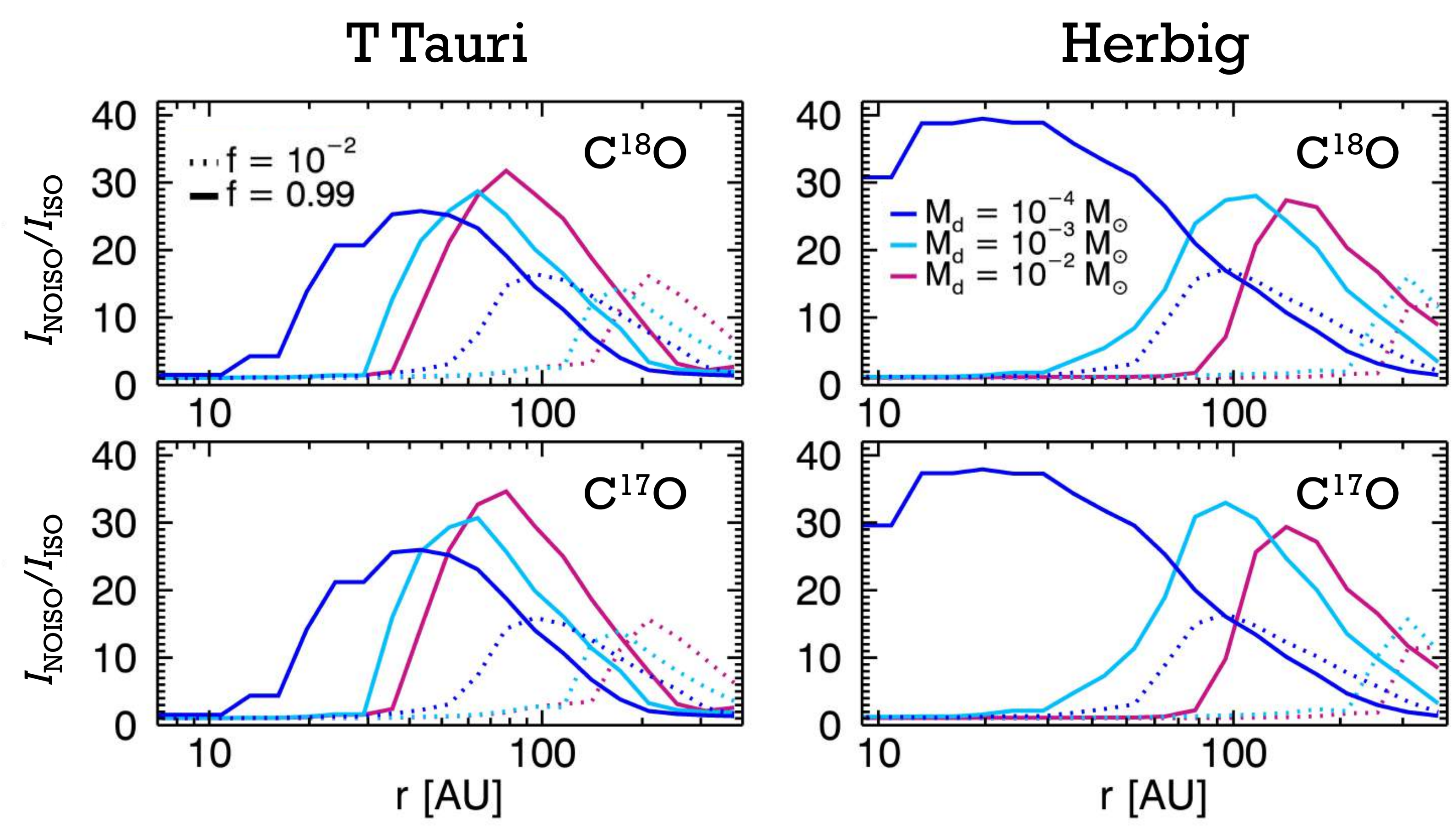


If isotope-selective photodissociation is considered, there are regions in the disk where $C^{18}O$ and $C^{17}O$ (panel e, f) show an underabundance with respect to ^{12}CO (panel a), when compared with the overall elemental abundance ratios.

4. Mass estimates

	True M_d [$M_\odot$]		Ratio(M_{True}/M_{NOISO})	
	small	large	small	large
	T Tauri		T Tauri	
$C^{18}O$	10^{-3}	10^{-3}	3.3	> 10
	10^{-2}	10^{-2}	12.5	> 10^2
$C^{17}O$	10^{-3}	10^{-3}	2.3	5
	10^{-2}	10^{-2}	3.6	40
	Herbig		Herbig	
$C^{18}O$	10^{-3}	10^{-3}	1.7	5.9
	10^{-2}	10^{-2}	1.7	14.7
$C^{17}O$	10^{-3}	10^{-3}	1.4	4.5
	10^{-2}	10^{-2}	1.3	10

3. Line intensity ratios



The line intensities obtained neglecting isotope selective photodissociation are higher up to a factor of 40 at certain disk radii.

[1]Bruderer et al., 2012