Spectral lines: avoid them or measure them?

E. Falgarone, C. Combet & J.F. Macias-Perez

Why should we worry about?

ν_0	Range	$\Delta \nu / \nu$	n_{det}	$ heta_{ m fwhm}$	σ_I per det		$\sigma_{(Q,U)}$ per det		Main molec. & atomic lines
					1 arcmin		1 arcmin		
GHz	GHz				μK_{RJ}	μK_{CMB}	μK_{RJ}	μK_{CMB}	
30	26-34	.25	50	17'	61.9	63.4	87.6	89.7	
36	31-41	.25	100	14'	57.8	59.7	81.7	84.5	
43	38-48	.25	100	12'	53.9	56.5	76.2	79.9	
51	45-59	.25	150	10'	50.2	53.7	71.0	75.9	
62	54-70	.25	150	8.2'	46.1	50.8	65.2	71.9	
75	65-85	.25	150	6.8'	42.0	48.5	59.4	68.6	
90	78-100	.25	200	5.7'	38.0	46.7	53.8	66.0	HCN & HCO ⁺ at 89 GHz
105	95-120	.25	250	4.8'	34.5	45.6	48.8	64.4	CO at 110-115 GHz
135	120-150	.25	300	3.8'	28.6	44.9	40.4	63.4	
160	135-175	.25	350	3.2'	24.4	45.5	34.5	64.3	
185	165-210	.25	350	2.8'	20.8	47.1	29.4	66.6	HCN & HCO ⁺ at 177 GHz
200	180-220	.20	350	2.5'	18.9	48.5	26.7	68.6	
220	195-250	.25	350	2.3'	16.5	50.9	23.4	71.9	CO at 220-230 GHz
265	235-300	.25	350	1.9'	12.2	58.5	17.3	82.8	HCN & HCO ⁺ at 266 GHz
300	270-330	.20	350	1.7'	9.6	67.1	13.6	94.9	
320	280-360	.25	350	1.6'	8.4	73.2	11.8	103	CO, HCN & HCO ⁺
395	360-435	.20	350	1.3'	4.9	107	7.0	151	
460	405-520	.25	350	1.1'	3.1	156	4.4	221	CO, HCN & HCO ⁺
555	485-625	.25	300	55"	1.6	297	2.3	420	C-I, HCN, HCO ⁺ , H ₂ O, CO
660	580-750	.25	300	46"	0.85	700	1.2	990	CO, HCN & HCO ⁺

CO might be a problem as it is for PLANCK !!

CO in Planck



CO in Planck

- Difficult to estimate the exact CO contribution: need very precise bandpass measurements per detector

- Major contaminant for dust at 100 GHz in the Galactic plane
- CO clumps and maybe diffuse emission at high-galactic latitudes (understanding limited by sensitivity)
- Affects polarization via bandpass mismatch leakage

But: CO science can be done with PLANCK !!!

High galactic latitude



Planck threshold for CO emergence



Lessons from PLANCK

➡CO at high galactic latitudes shows a power-law distribution of size and flux over hundreds of Planck identified patches

For these patches we find:

 F_{CO} α I_{CO} x θ² α θ^{1.9-2.5};
 ⇒I_{CO} α θ^{-0.1}

 Cannot rule out the presence of weak diffuse extended emission below the Planck detection threshold

➡Foreground science affected by CO emission

➡CO bandpass mismatch is very difficult to correct for

And CO polarisation



Golreich-Kylafis effect

Non-thermal populations of magnetic levels enhanced by I low gas density (levels populated by radiation, not collisions) anisotropic mm/submm

radiation (optical depth about

linewings only

I)

CO (2-1) Girart + 2004, Crutcher 2012 ARAA

Up to 10 % in star forming regions However, never measured in diffuse gas

What to do?

Data analysis easy option:

Filter out CO transition lines from start in the instrumental side - is this possible ?

More realistic option:

keep CO transition lines in the bandpass

multiple frequency bands around main CO line transitions

carefully measure bandpass, oversampling on molecular lines

Conclusions

Molecular lines and in particular CO are important foreground emissions in temperature

High galactic emission from CO has been observed with Planck on about 1% of the sky: mainly compact clouds but we can not exclude below detection threshold diffuse emission

CO emission is polarised up to 10 % on star forming regions in the linewings: theory predict polarisation enhanced for low column density but not measured yet

Best to avoid CO if possible, if not carefully measure bandpasses - this was a major problem for Planck