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OBSERVABILITY OF COMETS AND COMETARY TRAILS IN PLANCK DATA STREAMS

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SUMMARY – The comets and the dust released by them, sometimes assuming a shape as a trail as already detected by Iras, may represent an interesting subject for the Planck survey. In this work we performed some calculations on defining the chance to detect and to measure them. We focalized our attention on the CO production rate, as it represents the second molecule more abundant in a comet after the water, that is not easy to detect in the Planck channels. We determined a threshold, in terms of CO production rate, of 7×10^{27} molecule sec^{-1}. This threshold will allow to observe a large sample of long period and new comets, even at large heliocentric distances, where the statistic is very poor, due to the very few observations available in the outer Solar System. In such a way the Planck surveyor will help us to gain more insights on the CO physics and to detect new and already discovered comets at the CO frequencies. These points can become interesting even for the scientists involved in other subjects in order to correctly remove the Solar System object contributions from the Planck data, mainly when they appear as extended sources.

1 Introduction

In the last few years the interest on observing comets at radio wavelength increased substantially having a strong burst during the passages of the big comets Hyakutake (1996) and Hale-Bopp (1997). In these cases several new molecules have been observed for the first time in a comet allowing to gain more insights on the chemical behaviour of the coma at different heliocentric distances and to calculate some new isotopic ratios on common elements as nitrogen, oxygen and carbon. Furthermore it is the first time that a comet is observed at radio and optical wavelength at very large heliocentric distance, greater than 10 AU. All the radio observations made on comets are focalized on specific molecular emission and on well defined objects, there is no search of comets at these wavelengths.
The Planck ESA mission (Mandolesi et al. 1998, Puget et al. 1998) will offer a chance to

make a survey of these Solar System minor bodies at radio wavelength for the first time. In order to understand which is the possibility to observe a comet with Planck we took into account the production rate of the main molecules observed in these objects. The most important molecules observed in the comets are H_2O, considering that the water ice is the main component of these objects, and CO, present in a percentage of $1 \div 20$ % of the water abundance. As the direct observation of H_2O is difficult in a comet, because of the weakness of the line at 22.235 GHz and the dissociation of the molecule, most of the estimates of the water production rate are based on the radical OH detection at 1.667 GHz. The CO can be observed at 115.271 GHz (1-0), 230.538 GHz (2-1) and 345.796 GHz (4-3), that are well included in some Planck channels or at the edges of them. Other molecules as HCN, HNC, CS, CH_3OH and H_2CO could be in principle observed with Planck, at least at some transitions, but their production rates could be too low to be detected with the present sensitivities. So we preferred to take into account the CO, having the strongest known emissions included in the channels, in order to determine the feasibility of a scientific proposal for Planck. In a following work we will investigate on the chance to observe the comet at different frequencies taking into account these emissions and other not well known. Most likely such a further analysis will only concern very active and big comets.

2 Planck performances

The Planck surveyour will observe the sky at nine frequencies with different angular resolutions and sensitivities (see columns 1, 4 and 5 of Table 1). The relative bandwidth is somewhat different for the Low Frequency Instrument (LFI) (20%) and the High Frequency Instrument (HFI) (25%) (see column 2 of Table 1). The detailed frequency responses are not yet well defined; it is then clear that the detection constraints on comet fluxes and production rate based on lines at the edges of corresponding channels are accurate within multiplicative factors of some units.

Since the variability of the comet position, the comet detection can not easily take advantage from the twice covering of the sky in the 14 months of observations nor from the coadding of data from different feeds if they look at different sky positions at the same time. We report here the nominal Planck sensitivity per resolution element (a squared pixel with size given as Full Width at Half Maximum (FWHM) of the corresponding beams) as quoted in Puget et al. (1998) for the HFI and in the revision of LFI performances by Mandolesi et al. (1999) for the whole set of receivers, but rescaled to include several factors of sensitivity degradation.
A first factor $\sqrt{2}$ derives by considering only a single sky coverage and provides a lower limit to the sensitivity relevant here.
Another factor $\sqrt{N_{ric,sky}}$, where $N_{ric,sky}$, ranging from 2 to 17, is the number of radiometers or bolometers per channel pointing at the same sky position at the same time, take into account the displacement of the different receivers on the sky field of view. In column 3 of Table 1 we report the number of LFI radiometer (all intrinsically sensitive to polarization) and of the unpolarized and polarized HFI bolometers. For the HFI channels at 143 and 217 GHz the sensitivity on temperature fluctuation measurements quoted in Puget et al. (1998) is obtained by combining both unpolarized and polarized detectors whereas at 545 GHz only polarized detectors operate; for the upper limits on sensitivity quoted in Table 1 we consider a couple of polarized detector as equivalent to one unpolarized detector (for example, at 217 GHz, where we have 4 unpolarized detectors and 8 polarized detectors we use here $N_{ric,sky} = 4 + 8/2 = 8$). For the LFI channels $N_{ric,sky} = N_{rad}/2 = N_{feed}$, because we have 2 radiometers per feed horn. On the other hand in some cases a certain number of feeds look

Table 1: Instrumental and confusion noise estimates.

$\nu_{\rm eff}$ (GHz)	Band (GHz)	$N_{rad;bol}$ (unpol;pol)	FWHM (arcmin)	$\sigma_{\rm noise}$ (μK)	$\sigma_{\rm noise}$ (mJy)	$\sigma_{\rm CMB}$ (mJy)	$\sigma_{\rm ex.sou.}$ (mJy)	$\sigma_{\rm Gal}$ (mJy)
30	27.0÷33.0	4	33.6	7.2÷37.4	19.0÷98.8	85.2	74.2	100
44	39.6÷48.4	6	22.9	11.0÷75.8	29.0÷152.7	85.4	58.0	45
70	63.0÷77.0	12	14.4	15.0÷88.1	39.6÷232.7	79.2	39.5	15
100	90.0÷110.0	34	10.0	17.5÷144.6	45.5÷375.9	46.5	26.2	7
100	87.5÷112.5	4 ; 0	10.7	5.1÷21.1	15.1÷62.7	53.2	28.0	7
143	125.1÷160.9	3 ; 9	8.0	4.7÷22.8	15.9÷77.6	37.0	17.6	6
217	189.9÷244.1	4 ; 8	5.5	5.5÷28.4	20.5÷105.3	14.8	9.9	5
353	308.9÷397.1	6 ; 0	5.0	4.3÷14.9	34.8÷120.5	7.5	20.9	18
545	476.9÷613.1	0 ; 8	5.0	3.5÷10.0	68.3÷193.3	1.4	57.5	62
857	749.9÷964.1	6 ; 0	5.0	1.6÷5.7	77.9÷269.8	0.04	128.2	120

at some positions in the sky along the same scan circle, if they are located in the Focal Plane Unit to follow the sky scan direction as Planck satellite spins; this factor $\sqrt{N_{ric,sky}}$ gives a pessimistic value for the sensitivity estimate.
A last factor $\sim \sqrt{\rm FWHM/\Delta\theta_s}$, where $\Delta\theta_s$ is the spin axis shift between two consecutive hours (2.5 arcmin), takes into account the possibility that the comet falls out of the beam after a given spin axis repointing.
Taking into account all these degradation factors the nominal Planck sensitivities can be resumed in the ranges reported in the column 5 of Table 1; we provide also the same quantitities in terms of flux in the column 6.
The relationship between rms noises and temperature fluctuations in terms of antenna temperature and thermodynamic temperature is $\Delta\delta T_{ant} = \Delta\delta T_{therm} x^2 {\rm exp}x/({\rm exp}x - 1)^2$ and that between the rms flux fluctuations and the rms antenna temperature fluctuations on a squared pixel with side $\Delta\theta$ is $\Delta\delta B_\nu/{\rm Jy} = 30.7[\Delta\delta T_{ant}/{\rm mK}][\nu/{\rm GHz}]^2[\Delta\theta/{\rm rad}]^2$.

In addition to the instrumental noise, the sky itself exibits a confusion noise given by the various galactic and extragalactic temperature fluctuations and from the CMB anisotropies. At an angular scale $\theta \simeq 180^\circ/\ell$, corresponding to the multipole ℓ of the harmonic expansion of the fluctuation pattern, the rms temperature fluctuation is related to the angular power spectrum C_l by $\delta T \simeq \sqrt{\ell(2\ell+1)C_l/4\pi}$.

We report in Table 1 the fluctuation level of the CMB anisotropy on the beam scale, quoted on the basis of a standard flat model approximately COBE/DMR normalized, in agreement with the present constraints on CMB fluctuations at moderate multipoles; of course the true CMB confusion noise determination at small scales is the Planck main goal.

Then we report the combined confusion noise from Poisson fluctuations of extragalactic radiosources and infrared sources, as evaluated by Toffolatti et al. (1998) and revised by De Zotti et al. (1999a,b), for a conservative detection limit of 1 Jy. This provides pessimistic estimates, on the other hand it is probably difficult to realize a more accurate source subtraction in real time and we have also to take in mind that source clustering, neglected here, may increase the source confusion noise by a factor of few units, at least for some cosmological models.

The galactic fluctuation level reported here is only indicative and refers to moderate and high galactic latitude, as large variations are present in the sky.

Due to the combined effect of good sensitivity per receiver, the small level of foreground contamination, the decrease of CMB intensity with the frequency and the damping of CMB fluctuations at small scales, the best channels for the cometary gas detection seems to be the HFI ones in the range 100÷353 GHz.

An important requirement for the identification of the possible comets detected in the

Table 2: Relevant cometary molecular emissions in Planck bands.

Low Frequency Instrument

$\nu_{\rm eff}$/GHz	Band/GHz	Emissions
30	27.0÷33.0	
44	39.6÷48.4	
70	63.0÷77.0	
100	90.0÷110	CO(1-0), HCN(1-0), CS(2-1)

High Frequency Instrument

$\nu_{\rm eff}$/GHz	Band/GHz	Emissions
100	87.5÷112.5	CO(1-0), HCN(1-0), CS(2-1)
143	125.1÷160.9	CS(3-2), CH_3OH(3-2)
217	189.9÷244.1	CO(1-2)
353	308.9÷397.1	CO(3-2), HCN(4-3), HNC(4-3),
		CS(7-6), $H_2CO\left(\begin{smallmatrix}5_{05} & 4_{04}\\ 5_{23} & 4_{22}\end{smallmatrix}\right)$, CH_3OH(7-...)

Planck data streams is to miminize the delay for the follow-up to space and ground telescopes in other spectral bands. The Planck data rate telemetry and the frequency of data transmission at ground is still not well defined. It is highly probably that the data will be trasmitted to ground one time per day. A very accurate Planck telescope pointing reconstruction may require several days of data analysis; on the other hand a pointing reconstruction accuracy of ~ 10 arcmins can be reached on much shorter timescales. Then the main source of error in the evaluation of comet sky position is to ascribed to the comet motion during the time delay and is expected to be less than about 1 degree for comets at a distance from the sun larger than 1 AU. Therefore, the comet identification, for example through large field optical telescopes with small or moderate aperture, seems to be not a threat.

3 Gas

The flux received by a detector centered on the comet, produced by a transition τ of the molecule μ in a thin atmosphere approximation, can be described by the following equation, no taking into account the production of μ far from the nucleus in the extended sources:

$$\Phi_{\mu(\tau)} \simeq \frac{h\nu_{\mu(\tau)}}{\delta\nu} g_{\mu(\tau)} \frac{Q_\mu \Theta \Delta}{2v_\mu} \frac{1}{4\pi\Delta^2}, \tag{1}$$

where $\Phi_{\mu(\tau)}$ is the radiation flux at the receiver, $\delta\nu$ the detector bandwidth, h the Planck constant, $\nu_{\mu(\tau)}$ the emission frequency, $g_{\mu(\tau)} \equiv g_{\mu(\tau)}(r, \dot{r})$ called *g-factor* is the photon emissivity for the transition $\mu(\tau)$ per molecule per second, Q_μ is the production rate for the molecule μ, Θ the beam width, Δ the distance between the probe and the comet, v_μ the velocity of the molecular specie μ relative to the cometary nucleus.. The $g_{\mu(\tau)}Q_\mu\Theta\Delta/2v_\mu$ term is the number of molecules in the detector beam scaled by the photon emissivity. Approximating $\delta\nu/\nu_{\mu(\tau)}$ with $\delta\nu/\nu$ (ν being the detector central frequency):

$$\Phi_{\mu(\tau)} \simeq 1.025 \times 10^{-25}\,\mathrm{Jy}\,\frac{\nu}{\delta\nu}\, g_{\mu(\tau)}\, Q_\mu \left[\frac{\Delta}{\mathrm{AU}}\right]^{-1} \left[\frac{\Theta}{\mathrm{arcmin}}\right] \left[\frac{v_\mu}{\mathrm{Km/sec}}\right]^{-1}. \tag{2}$$

Assuming the detector sensitivity $\phi_{\rm th}$ the lower limit for the production rate required to detect the comet through the transition $(\mu(\tau))$: $Q_{\min,\mu(\tau)}$, is:

$$Q_{\mathrm{min},\mu(\tau)} \simeq 3.9024 \times 10^{26}\ \frac{\mathrm{molecules}}{\mathrm{sec}}\ \frac{\delta\nu}{\nu}\ \frac{1}{g_{\mu(\tau)}}\ \left[\frac{\phi_{\mathrm{th}}}{\mathrm{Jy}}\right] \left[\frac{\Delta}{\mathrm{AU}}\right] \left[\frac{\Theta}{\mathrm{arcmin}}\right]^{-1} \left[\frac{v_\mu}{\mathrm{Km/sec}}\right]. \quad (3)$$

We consider the CO(1-0) emission at 115.271 GHz for $r_{\mathrm{h}} = 1$ AU, assuming a pixel size of 10 arcmin, $\delta\nu/\nu = 0.25$, $g_{\mathrm{CO}} \approx 2.6 \times 10^{-4}$ photons/sec molecule, $v_{\mathrm{CO}} \approx 1$ km/sec, $\Delta = 1$ AU and $\phi_{\mathrm{th}} = 200$ mJy we obtain a threshold sensitivity $Q_{\mathrm{min,CO}} \simeq 7 \times 10^{27}$ molecules/sec.
The pitch angle between spin axis and pointing direction plus the probe orientation referred to the Sun fixes the range of the heliocentric distances r_{h} and probe - comet distances Δ at which a comet may be detected. Assuming a circular orbit for Planck located in L2, with pitch angle 90° and spin angle aligned with the Sun direction:

$$r_{\mathrm{h}}(\Delta) \simeq \sqrt{(1.01\ \mathrm{AU})^2 + \left[\frac{\Delta}{\mathrm{AU}}\right]^2}\ ; \quad (4)$$

it yields that a comet at r_{h} lower than 1 AU can not be detected.
We could assume $g_{\mu(\tau)} \propto 1/{r_{\mathrm{h}}}^2$, even if this is only a rough approximation. Indeed, the coma is an highly non collisional medium (density $\approx 10^4 \div 10^5$ molecules/cm^3), many lines are due to forbidden transitions, and when the molecules are the product of chemical reactions occurring in the coma one should take into account that further reactions could take place on the same radicals, making more complex the dependence from the heliocentric distance. However for parent molecules (and many daughter molecules) most of the emission is driven by solar photons excitation and spontaneous de-excitation, the emission rate will become a function of the overall photon flux, i.e. the heliocentric distance r_{h}, and of the radial molecular velocity $\dot{r}_{\mathrm{h},\mu} \approx \dot{r}_{\mathrm{h}} + v_\mu$, that is affected by the Swing and Greenstein effects. The Swing effect is due to the Doppler shift induced by the comet heliocentric velocity $\dot{r}_{\mathrm{h}}$, that implies a modulation of the solar photon flux, working on the cometary molecules, by the Fraunhofer lines in the solar spectra. While the Greenstein effect depends from the motion of the radicals inside the coma. However for the estimates we are going to provide, in a first approximation, we will neglect these effects in order to assume the simple law $1/{r_{\mathrm{h}}}^2$.
The molecular velocity v_μ depends from the production mechanism. For parent molecules who directly sublimates from the icy nucleus it will depend on the surface temperature and r_{h}, while for the daughter molecules also the reaction kinetic can be important. Since most of the comets are water driven, many secondary parent molecules are embedded into the water ice as hydrates, so that one may take $v_\mu \approx v_{\mathrm{H_2O}}$ typically $v_{\mathrm{H_2O}}(r_{\mathrm{h}} = 1\ \mathrm{AU}) \approx 1$ km/sec which is also used as a typical velocity for daughter molecules. Assuming thermal equilibrium between the nuclear surface and the solar radiation, the temperature of the nucleus will decrease as $\approx 1/{r_{\mathrm{h}}}^2$ and correspondingly v_μ decreases as $1/r_{\mathrm{h}}$. Deviations from this simple relation are due to the thermal inertia of the icy layers underneath the surface. The situation changes for $r_{\mathrm{h}} \gtrsim 3$ AU where water should not sublimate, nevertheless observations shows that comets may be active even at larger heliocentric distances. In some cases far active comets are CO driven and the heliocentric distance dependence is thermal again, otherwise molecules have to diffuse through the surface and v_μ will be somewhat smaller than thermal velocity owing to the increased extraction work.
Even the production rate Q_μ will be proportional to $1/{r_{\mathrm{h}}}^2$ when thermal delay effects are neglected. For a water or CO driven comet $Q_\mu \approx f_\mu\, Q_{\mathrm{d}}$ where f_μ is the fractional abundance of the specie μ respect to the driving specie d (H_2O or CO), for a water hydrate $f_\mu \approx 1 - 10\%$.
Combining all these results one may conclude:

$$Q_{\mathrm{min},\mu(\tau)}(r_{\mathrm{h}}) \approx Q_{\mathrm{min},\mu(\tau)}(r_{\mathrm{h}} = 1\mathrm{AU}) \left[\frac{r_{\mathrm{h}}}{\mathrm{AU}}\right]^2 . \quad (5)$$

Figure 1: Visibility of the CO emission computed for $\theta = 10$ arcmin (central band delimited by the continuous lines) as a function of $r_{\rm h}$. The band lower limit is computed assuming a constant $v_{mu} = 1$ km/sec at any $r_{\rm h}$, the upper limit assuming a $1/r_{\rm h}$ dependence. Two further cases are considered: $\theta = 5$ arcmin (dot-dashed lines) and $\theta = 20$ arcmin (dashed lines). The vertical bars are the expected $Q_{\rm CO}$ for the comets reported in Table 5, lower and upper limits are for $Q_{\rm CO}/Q_{\rm H_2O} = 0.01$ and 0.10 respectively. For completeness even comets observed at $r_{\rm h} < 1$ AU are reported. The y-axis show the Q_{CO} in a logarithmic scale and the crosses point at $Q_{CO} = 0.05 Q_{H_2O}$, the labels have been defined in Table 5.

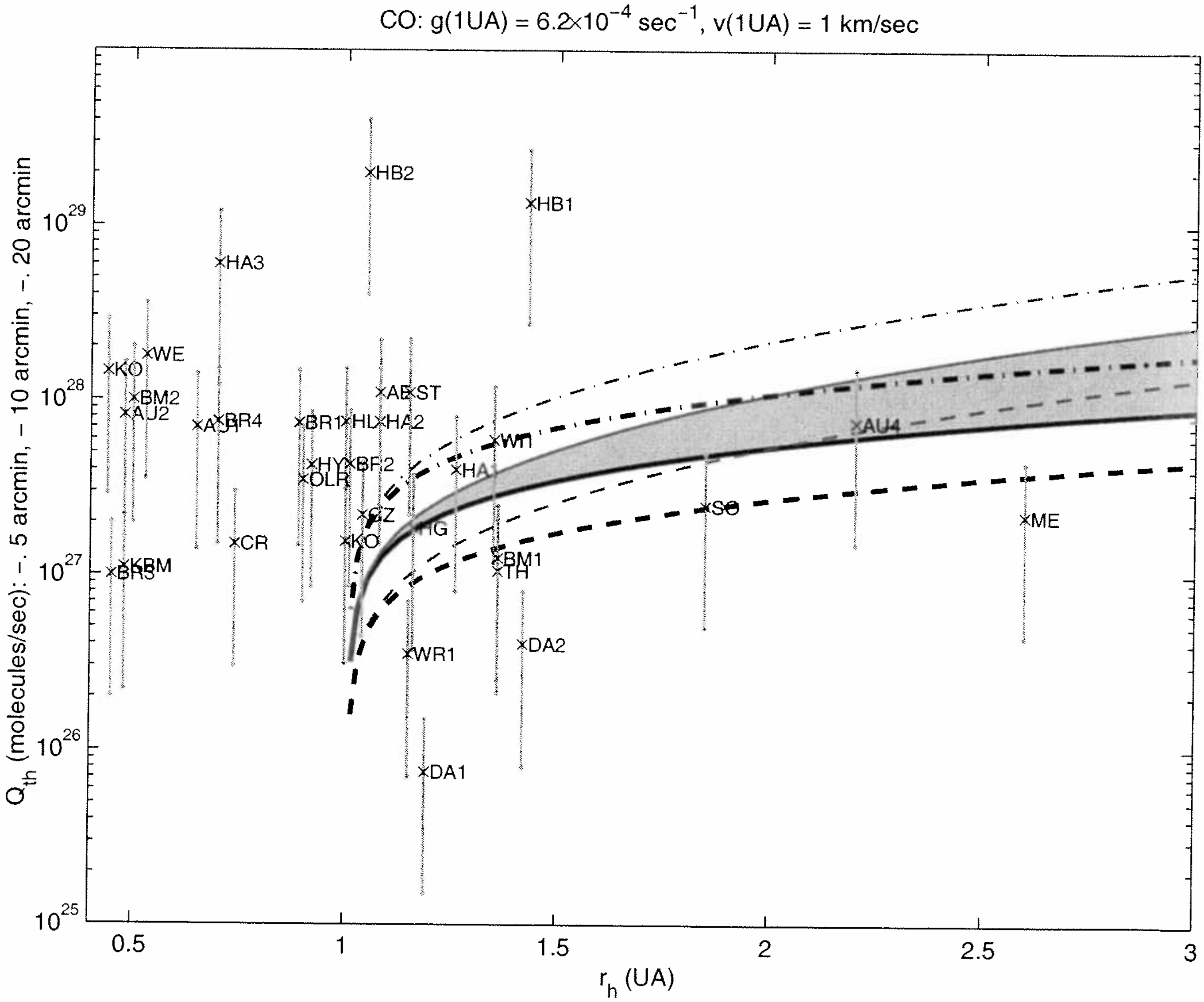

Table 3: Expected fluxes and S/N ratios per beam for the 857 GHz HFI channel of the fluxes from comets observed by COBE and ISO.

Comet/Mission	Measured λ (μm)	HFI 857 GHz Expected Flux (mJy/arcsec^2)	Flux (mJy)	S/N	r_h (AU)	Δ (AU)	Ref.
SW3/COBE	25	7×10^{-2}	43	~ 0.4	1.0	0.6	Lisse et al. (1998)
Gunn/ISO	15	2	500	~ 5	2.6	2.0	Colangeli, et al. (1998)
Wirtanen/ISO	15	0.3	70	$\lesssim 1$	1.8	1.7	"

The results of such calculation for three choices of the angular resolution and in the range of distances for water sublimation are reported in figure 1 together with the Q_{CO} rates for typical small and large comets. It is possible to see how even relatively small comets would be detectable by Planck. However, when r_h approaches the 3 AU limit competitive effects not considered here may change significantly the prediction. The first one is the already discussed change in the sublimation mechanism, if as a consequence v_μ drops following the $1/r_{\rm h}$ scaling rule, $Q_{{\rm min},\mu(\tau)}$ will drop correspondingly due to the higher CO density near the nucleus. Since for CO at $r_{\rm h}=$ 1 AU the photodissociation rate is $f_{\rm CO} = 6.5 \times 10^{-7} sec^{-1}$, which scales as $1/{r_{\rm h}}^2$, the free mean path against photodissociation is $\approx 1.5 \times 10^6$ Km. So for $\Delta \gtrsim 3$ AU the amount of gas framed by a beam will not increase at larger Δ, compensating the previously expected decrease in $Q_{{\rm min},\mu(\tau)}$. A proper evaluation of these effects are in progress.

4 Dust

The dust is a major component of a comet and a dust to gas ratio about one may be considered a good guess in order to perform our calculations. Moreover, for comets at heliocentric distances of 1-2 AU may be reasonably assumed $Q_{\rm Dust} \propto 1/{r_{\rm h}}^2$. However large variations both for the $Q_{\rm Dust}$ heliocentric distance dependence and the dust to gas ratio are expected from object to object. In millimetric and sub-millimetric bands the dust emission could be assumed thermal, even if at high wavelengths the particle size distribution begins to be important implying a diversion from the black body law, with $T_{\rm BlackBody} \approx 3 \times 10^2$ K so that $I_{\rm Dust} \propto 1/\lambda^2$. A simple calculation shows that cometary dust will affect the highest frequency channels of the HFI instrument, in particular the 857 GHz channel. Assuming for this channel a sensitivity of about 10^2 mJy, in table 3 we report the signal and the S/N ratio expected from the comets observed by COBE and ISO in the same observational conditions ($r_{\rm h}$, Δ). The expected signal is obtained by:

$$S_{\rm HFI} \sim \Theta^2 \frac{\lambda_{\rm M}}{\lambda_{\rm HFI}} \Phi_{\rm Obs} \tag{6}$$

where $\lambda_{\rm HFI} \approx 300$ μm. With the aforementioned ratios $Q_{\rm Dust} : Q_{\rm H_2O} : Q_{\rm CO} \approx 1 : 1 : 0.1$ it is possible to see that in the higher frequency channels the gas contribution will be overwhelmed by the relevant dust contamination.

A further contribution due to the cometary dust should be taken into account and it is represented by the trails, already observed from the IRAS mission. These large features are due to the dust released by the comets and left along its orbit, they can reach a length of tens of degrees and a width of few arcmins.

Table 4: CO production rates for various observed comets.

Comet	r_h (AU)	H_2O 10^{28} mol s^{-1}	CO (% on H_2O)	Ref.
Hale-Bopp			12	Di Santi et al. (1999)
Hyakutake			22	Biver et al. (1999)
C/1999 H1 Lee		5-15	5	Bockelee-Morvan et al. (1990)
Halley			17-20	Woods et al. (1986)
Halley			5-15	Eberhardt et al. (1987)
Austin (1989c1)		11	1-3	Mumma et al. (1990)
Levy (1990c)			11	Feldman et al. (1991)
Levy (1990c)			13	Weaver et al. (1991)
Swift-Tuttle (1992t)		20		Paubert et al. (1992)
SW1			5×10^{28}	Crovisier et al. (1995)
Chirone	9.32		4×10^{28}	Womack & Stern (1995)
Giacobini-Zinner		5	2-3	Bockelee-Morvan et. al. (1999)
Bradfield 1979 Y1	0.7	15	3-4	Feldman et al. (1997)
West 1976 VI		15	3.9×10^{28}	Crovisier et al. (1983)

IRAS observed for the first time the trails at 100μ measuring a peak flux of 200 mJy/arcmin^2, taking into account a Planck distribution at 350μ, corresponding to the highest frequency of HFI, we find about 20 mJy/arcmin^2. This value converted to the pixel size of Planck, 5×5 arcmin^2, yields about 500 mJy/pixel, well above the threshold of the 857 GHz channel.

5 Discussion

According to the sensitivity of the channels where the CO can be revealed several comets can be detected at heliocentric distances lower than 3 AU, that is when the water ice starts to sublimate and the cometary nucleus starts to warm up due to the solar radiation. This process should work mainly for short period comets that are small and aged objects and only a minor number of them could be detected by Planck. Table 4 reports the direct measurement of CO on some comets, while Table 5 shows the water production rate and assuming a CO abundance of 5-10% with respect to the water we can have an idea on a possible sample of objects visible by Planck. Most of them are long period and new comets. Then we emphasize a further point of interest consisting in the discovery of new comets, even at lower heliocentric distances, as the Planck survey will cover the region at 90^o of elongation and the quick look of the data should allow to find soon the new objects.
At heliocentric distances higher than 3 AU it is usually assumed that the comet activity is driven by the CO sublimation and very few objects have been observed at these frequencies so far from the Sun. There are two well known examples as the short period comet Swassmann-Wachmann 1 and the long period comet Hale-Bopp. In the first case the comet has a quasi circular orbit, nearby the Jupiter one, and it is never at heliocentric distances lower than 3 AU, in other words most of the water ice cannot sublimate. It has been discovered by chance because of its high dust production that can be driven only by an high CO production rate, as it has been confirmed by radio observations. The discovery of this comet was easier as it shows frequently strong burst sometimes characterized by an increase of brightness of few magnitudes. We cannot rule out that many other short period comets similar to the SW-1 are not yet discovered not suffering strong bursts, but having an important CO production

Table 5: Water production rates for various observed comets. The second abbreviated labels in the second column are used to labels points in Figure 1.

Comet		r_h (AU)	H_2O 10^{28} mol s^{-1}	Ref.
Hale-Bopp	HB1	1.43	270	Dello Russo et. al. (1997)
Hale-Bopp	HB2	1.05	400	"
Hyakutake	HY	0.92	8.5	Biver et. al. (1999)
C/1999 H1 Lee	HL	1	15	Bockelee-Morvan et. al. (1999)
Halley	HA1	1.26	8	Bockelee-Morvan et. al. (1999)
Halley	HA2	1.08	15	"
Halley	HA3	0.7	120	"
Austin 1982 VI	AU1	0.65	14	"
Austin 1984 XIII	AU2	0.48	16.3	"
P/Giacobini-Zinner 1985 XIII	GZ	1.04	4.4	"
Hartley-Good 1985 XVII	HG	1.16	3.7	"
Thiele 1985 XIX	TH	1.36	2.1	"
Wilson 1987 VII	WI1	1.35	11.8	"
Sorrells 1987 II	SO	1.85	5	"
Bradfield 1987 XXIX	BR1	0.89	14.7	"
Bradfield 1987 XXIX	BR2	1.01	8.6	"
Austin (1989c1)	AU3		11	Mumma et. al. (1990)
Kohoutek 1973 XII	KO	0.44	28.9	Despois et. al. (1981)
Kobayashi-Berger-Milon 1975 IX	KBM	0.48	2.2	"
Weat 1976 VI	WE	0.53	35.5	"
6P/D'Arrest 1976 XI	DA1	1.19	0.15	"
Kohler 1977 XIV	KO	1	3.1	"
Bradfield 1978 VI	BR3	0.45	2	"
Meier 1978 XXI	ME	2.6	4.4	"
Levy (1990c)	LE1	1.24	12.5	Feldman et. al. (1991)
Bradfield 1979 Y1	BR4	0.7	15	Feldman et. al. (1997)
Wilson 1986l	WI2	14/4/87	25	Larson et. al. (1987)
P/Brorsen-Metcalf 1989o	BM1	1.36	2.5	Schultz et. al. (1989)
P/Brorsen-Metcalf 1989o	BM2	0.5	20	Bockelee-Morvan et. al. (1990)
Okasaki-Levy-Rudenko 1989r	OLR	0.9	7	"
Aarseth-Brewington 1989a1	AB	1.08	22	"
Austin 1989c1	AU4	2.2	15	Roettger et. al. (1989)
P/Swift-Tuttle	ST	1.15	22	McFadden et. al. (1992)
6P/D'Arrest	DA2	1.42	0.8	Mumma et. al. (1995)
46P/Wirtanen	WR1	1.15	0.7	Bertaux et. al. (1997)
46P/Wirtanen	WR2	perihelion	2.7	Fink et. al. (1998)
27P/Crommelin 1983n	CR	0.74	3	Feuston et. al. (1984)

rate.
In the case of the long period and new comets the orbital inclination distribution is random and they can be discovered anywhere and because of their few passages at the perihelion they can be very active. The Hale-Bopp showed an high CO production rate beyond 10 AU from the Sun.
The real problem is the poor knowledge of the CO physics in the cometary coma and its velocity, making very difficult good predictions on observing the comets at large heliocentric distances. The Planck survey could provide very important information on the distribution of the comets CO driven allowing also to discover new far objects and to follow the evolution of the CO production rate.
Our report didn't mention any other molecule, in terms of calculations and prediction about their detection, as they commonly are less abundant than the CO and they have a lower g-factor, but we cannot rule out the chance to observe them in some peculiar object.
The observation of the comets is not limited to the gas emissions at the specific frequencies we mentioned above, but they can be detected and studied looking at the dust production. It is possible to observe about half of the comets looking at the dust, but only to the highest HFI frequency. At this frequency any gas emission could be embedded in the dust, while at lower frequencies the dust continuum is dominated by the gas. In other words the gas and dust components can be complementary in the Planck observations of comets.
Furthermore there will be an interesting chance to study the dust trails and the observations performed at the 857 GHz channel will allow to model the fluxes of these features helping us to detect them at lower frequencies.

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