67P/Churyumov-Gerasimenko mass determination based on a new method for modeling non-gravitiational forces and accelerations. L. Maquet[1], F. Colas[1], L. Jorda[2] and J. Crovisier[3], [1]IMCCE - Observatoire de Paris, Paris, France (maquet@imcce.fr), [2]LAM – Marseille, France [3]LESIA – Observatoire de Paris, Paris, France .

Introduction: We developed a method based on a new approach to model cometary non-gravitational forces and accelerations . Our aim is to determine the physical parameters of the nucleus and also perform more reliable ephemeris. We applied this method to comet 67P/Churyumov-Gerasimenko, target of the Rosetta mission. We determined the fraction of active area, the rotational axis orientation, the mass and the density of the nucleus. This parameters are important for the success of the mission. Our goal is to have a simple but realistic model without too many parameters unlike Sekanina (2004) [1].

The method: We developed a physical and dynamical model taking into account the non-gravitational forces due to the water outgassing from the nucleus.

Hypothesis: The nucleus is modeled as a triaxial ellipsoid divided into latitudinal bands (Fig. 1). In fact, we just average the non gravitational forces during one nucleus rotation which is always short compare to the orbital revolution.

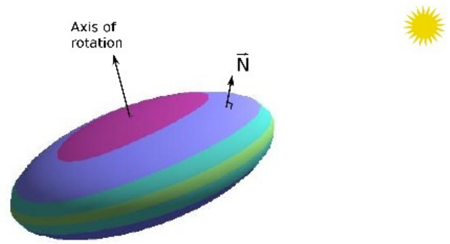

Fig. 1 : Geometrical view of a modeled nucleus with seven latitudinal strips.

The thermal inertia is neglected and the gas velocity is considered proportional to the thermal gas velocity. These hypotheses allow seasonal effects.

Calculations of the total acceleration: The non-gravitational acceleration (NGA) depends on the nucleus mass and on coefficients (C_i) reflecting the activity of each band (C_i=0 if the band is not outgassing and C_i=1 if the whole band is outgassing). It also depends on the surface of the bands, the water sublimation rate, the velocity and the mass of the ejected molecules. The total NGA is a linear combination of each band NGAs.

From astrometrical measurements, we fit the C_i/M_C ratios, where M_C is the mass of the nucleus. To determine the total NGA, we also calculate the total water production rate as a linear combination of the water production rate of each band. We optimize the coefficients C_i from water production rate measurements. From the C_i/M_C ratios and the C_i coefficients, we can deduce the mass of the nucleus and its density if the volume is known. We remark that the total NGA depends on the orientation of the rotational axis. A χ^2-map is drawn in relation with the direction of the rotational axis.

Results on 67P/Churyumov-Gerasimenko:

Fit of the astrometrical measurements: We determined the physical parameters with a model based on three bands. After fitting the astrometrical measurements, we found a reduced- χ^2 equal to 1.04, better than the one computed using Marsden et al. (1973)[2] model.

*Determination of the position of the rotational axis:*From the χ^2-map (Fig. 2), we found that the optimal axis of rotation is (α=150°±25°,δ=25°±25°) or (α=330°±25°,δ=-25°±25°) which correspond to the same solution with a opposite direction of rotation.

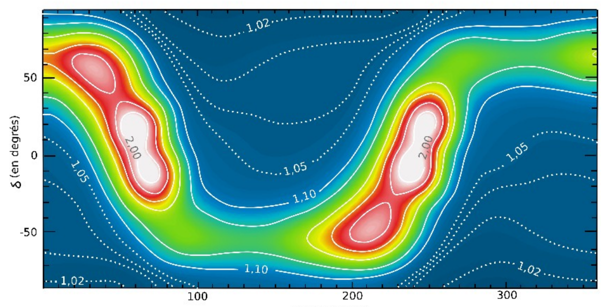

Fig. 2 : χ^2-map for the determination of the rotational axis.

Determination of the mass and of the nucleus density: Thanks to the water production rates measurements, we deduce that the nucleus is more active at low latitudes (on the equatorial band). Moreover, we obtained the nucleus mass of: $3.14\times10^{12}\pm0.21\times10^{12}$ kg. This mass corresponds to a density equal to 102±9 kg m^{-3}. This determination is consistent with those obtained by other authors ([3],[4]).

References:

[1] Sekanina Z. (2004) Journal of Geophysical Research, Volume 108, [2] Marsden B. G. et al. (1973) *AJ, 78*, 211–225. [3] Davidsson B. J. R. and Gutiérrez P. J. (2005) *Icarus, 176,* 453-477. [4] Rickman H. et al. (1987) *ESA special publications,* .