International Workshop On Comets In Honor of Hans Rickman

Rapport sur les contributions

https://indico.obspm.fr/e/workshop_hans_rickman

ID de Contribution: **3** Type: **Talk**

The Oort cloud: shape and dynamics

mercredi 18 mai 2016 09:15 (45 minutes)

We will present our last results on the long term dynamics of the Oort cloud comets. It particular the final shape of the Oort cloud and its dependency on the initial condition sample will be investigated. The relations between the final shape and present flux of observable “new” long period comets are also highlighted.

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Orateur: FOUCHARD, Marc

Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **6** Type: **Talk**

Comets as collisional fragments of larger planetesimals

mercredi 18 mai 2016 12:00 (45 minutes)

Comets are often thought of as “pristine planetesimals”. However, most cometary objects that we study are just a few km in size. Planetesimals this small are highly unlikely to be pristine planetesimals. In fact, the collisional environment in the trans-Neptunian planetesimal disk was very severe both before and during the giant planet instability phase that formed and sculpted the current comet reservoirs (the scattered disk and the Oort cloud). Km-size planetesimals had no chance to survive intact this collisional phase. Thus, the comets that we observe should be regarded as collisional fragments of larger planetesimals, like NEAs are regarded as collisional fragments of larger asteroids. The primitive character of comets is just a myth.

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Classification de Session: The physics of comets

Classification de thématique: The physics of comets

ID de Contribution: **7** Type: **Talk**

Long period comet encounters with the planets: an analytical approach

mercredi 18 mai 2016 10:00 (45 minutes)

Close encounters with the giant planets play an important role in the evolution of the orbits of long period comets, and have been treated in a number of papers. We revisit the subject in the framework of an analytic theory of close encounters, that provides useful insight on the properties of the strong perturbations caused by planetary encounters.

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Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **9** Type: **Talk**

Oort cloud and Scattered Disc formation during an episode of giant planet instability

mardi 17 mai 2016 16:00 (45 minutes)

I discuss how the proposed instability of the giant planets that sculpted the Kuiper Belt and Scattered Disc also formed the Oort comet cloud. I show the results of numerical simulations of this problem and discuss formation efficiency, number of comets in the cloud and the Oort cloud to Scattered Disc population ratios. I compare these with observations and give an updated estimate based on the fading of Jupiter-family comets. These results indicate that the Oort cloud and Scattered Disc formed simultaneously and that the observed population ratio matches numerical simulations.

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Orateur: Dr RAMON, Brasser (Institute for Astronomy and Astrophysics, Taiwan)

Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **10** Type: **Talk**

The relative contribution of the Oort cloud and the scattered disc to the short-period comet population

mardi 17 mai 2016 11:00 (45 minutes)

We discuss how many comets come to short-period orbits from different sources in the outer solar system. The observed distribution of Centaurs, as a transition population, plays a pivotal role in constraining our models. We show that the Oort cloud and the scattered disc produce similar numbers of Jupiter-family comets.

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Orateur: Prof. EMEL'YANENKO, Vacheslav (Institute of Astronomy, RAS)

Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **11** Type: **Talk**

Increasing knowledge and understanding of dynamical history of the observed Oort spike comets

mardi 17 mai 2016 14:00 (45 minutes)

Galactic and stellar perturbations are important factors when studying the past and future motion of the observed Oort spike comets. Since our knowledge on the Solar System Galactic environment is continuously increasing it is necessary to upgrade our methods and computer codes for taking into account these perturbations in a proper way. I will report our preparations to incorporate new and hopefully revolutionary data from the Gaia mission into our dynamical model of the cometary orbit evolution. Some test results will also be presented.

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Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **12** Type: **Talk**

The chemical diversity and isotopic ratio in comets

mercredi 18 mai 2016 15:00 (45 minutes)

For the last 3 decades, infrared and especially microwave techniques have enabled the detection of up to 26 different parent molecules in the coma of comets. Several molecules have been detected in over 40 different comets. A large diversity of composition is seen in the sample, comprising comets of various dynamical origin. Abundances relative to water for the molecules can vary by a factor 3 to more than 10. The taxonomic study of a sample of comets in which the abundances of several molecules (e.g., HCN, CH_3OH, CO, CH_4, C_2H_6, H_2S, H_2CO, CH_3CN, CS,...) have been measured does not show any clear grouping. Except for fragments of a common parent comet, every comet observed shows a different composition. Isotopic ratios such as $^{13}C/^{12}C$, $^{34}S/^{32}S$, $^{15}N/^{14}N$ and D/H have been measured in some molecules and could also give clues on the origin of cometary ices. In comparison to Earth values, a twofold enrichment in ^{15}N is observed and the D/H ratio in water varies between 1x and 4x the Earth oceans value. The absence of any clear correlation between the volatile content and the D/H ratio of the comets and their dynamical origin (Kuiper Belt versus Oort Cloud) suggest that there is no clear dychotomy between two origins for the comets. Their diversity in composition may also suggest that radial and temporal mixing in the early protoplanetary nebula may have played an important role.

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Orateur: BIVER, Nicolas

Classification de Session: The physics of comets

Classification de thématique: The physics of comets

ID de Contribution: **13** Type: **Talk**

VIRTIS/Rosetta observes Comet 67P/Churyumov-Gerasimenko: Nucleus derived composition and physical properties.

jeudi 19 mai 2016 12:00 (45 minutes)

The paper will describe the major results obtained so far by the Visible, Infrared and Thermal Imaging Spectrometer (VIRTIS), the dual channel spectrometer onboard Rosetta, on the surface composition and physical properties of the nucleus of comet 67P/Churyumov-Gerasimenko and the implications on the origin and evolution of the nucleus.
These results were achieved studying the reflected and emitted radiance of the comet in the spectral range 0.25-5.0 μm with a Mapping Spectrometer (VIRTIS-M) and a High Resolution Spectrometer (VIRTIS-H) (1). The nucleus observations were performed with spatial resolution varying from the initial 500m down to 2.5m and have generated compositional maps of the illuminated areas. The nucleus integrated normal albedo has been calculated as 0.060 ± 0.003 at 0.55 μm (2), and reflectance spectra display distinct gradients in the VIS and IR regions (5-25 and 1.5-5 % kÅ-1 respectively). These results suggest a surface made of an association of carbon bearing species and opaque minerals such as sulfides. In addition a broad absorption feature in the 2.9-3.6μm range has been observed; this band is present across the entire illuminated surface and, its shape and width are compatible with absorptions due to non-volatile organic macromolecular materials, complex mixture of various types of C-H and/or O-H chemical groups (3,4). Ice rich regions of limited extent have also been observed either as an ephemeral source, resulting from the diurnal re-deposition at the surface of water ice sublimating in the interior (5), or as temporally stable regions, resulting from exposure of deeper layers after landslides or debris falls. Spectral modeling of these regions has pointed out the presence of a wide range of sizes of water grains, ranging from few μm to several mm. The implication of this finding in terms of the evolutionary processes that may have affected and shaped the surface of 67P/CG will be discussed.

Authors acknowledge the support from national funding agencies.

References
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5- De Sanctis et al, Nature (2015)
6- Filacchione et al., Nature (2016)

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Orateur: CAPACCIONI, Fabrizio (IAPS-INAF)

Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission

ID de Contribution: **14** Type: **Talk**

Activity of comets : clues from comet 67P/Churyumov-Gerasimenko

jeudi 19 mai 2016 11:15 (45 minutes)

Cometary activity involves complex processes, which are related to the thermal history of the comet nucleus and evolutionary effects, and depend on the nature and properties of surface and subsuface material. Whereas ground-based observations provided insights on the volatiles responsible for cometary activity and showed evidence for non-uniform activity and seasonnal effects, a thorough understanding of cometary activity requires spatially resolved investigations of surface/subsurface/inner coma properties and their evolution along the comet orbit. This talk will provide an overview of results obtained on the gaseous activity of comet 67P/Churyumov Gerasimenko from Rosetta instruments.

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Orateur: Prof. BOCKELÉE-MORVAN, Dominique (LESIA)

Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission

ID de Contribution: **15** Type: **Talk**

A concurrent comet and TNO formation scenario

mercredi 18 mai 2016 14:15 (45 minutes)

For decades, comet scientists have debated whether comet nuclei are primordial rubble piles, formed at their current sizes through gentle accretion in the Solar Nebula, or if they are collisional rubble piles formed in the aftermath of violent collisions between larger parent bodies. The Rosetta mission to comet 67P/Churyumov-Gerasimenko and the Stardust sample-return mission to comet 81P/Wild 2, combined with observations by Cassini or from ground of irregular giant planet satellites captured from the primordial disk, have provided a variety of physical, mineralogical and chemical information that allow us to revisit the problem of comet formation with greater confidence than previously.

The emerging picture is that thermal processing due to short–lived radionuclides, combined with collisional processing during accretion in the primordial disk, is expected to create a population of medium–sized bodies that are comparably dense, compacted, strong, heavily depleted in supervolatiles and that have experienced extensive aqueous alteration due to the presence of liquid water. Irregular satellites Phoebe and Himalia are potential representatives of this population. Collisional rubble piles inherit these properties from their parents. Contrarily, comet nuclei have low density, high porosity, weak strength, are rich in supervolatiles, and do not display convincing evidence of in situ aqueous alteration. Therefore, comet nuclei do not resemble collisional rubble piles, but display all properties expected for primordial rubble piles.

We outline a comet formation scenario that starts in the Solar Nebula and ends in the primordial disk, that reproduces these observed properties, and additionally explains the presence of extensive layering on 67P/Churyumov–Gerasimenko (as well as on 9P/Tempel 1 observed by Deep Impact), its bi–lobed shape, the extremely slow growth of comet nuclei as evidenced by recent radiometric dating, and the low collision probability that allows primordial nuclei to survive the age of the Solar System.

We argue that TNOs formed due to streaming instabilities at sizes below ~ 400 km and that ~ 350 of these grew slowly in a low–mass primordial disk to the size of Triton, Pluto, and Eris, causing little viscous stirring during growth. We thus propose a dynamically cold primordial disk, that prevented medium–sized TNOs from breaking into collisional rubble piles, and allowed for the survival of primordial rubble–pile comets. We argue that comets formed by hierarchical agglomeration out of material that remained after TNO formation, and that this slow growth was a necessity in order to avoid thermal processing by short–lived radionuclides (that would have led to aqueous alteration and loss of supervolatiles), and that allowed comet nuclei to incorporate ~ 3 Myr old material from the inner Solar System.

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Classification de Session: The physics of comets

Classification de thématique: The physics of comets

ID de Contribution: **16** Type: **Talk**

Warsaw Catalogue of long-period comets

mardi 17 mai 2016 14:45 (45 minutes)

Currently, this Catalogue includes orbits of about 160 Oort spike comets defined as objects with original 1/a less than 0.000100 au^{-1}. Orbits were determined or redetermined in a completely homogeneous way and constitute more than 85% of the Oort spike comets discovered before 2010. In the publicly available Catalogue, we offer observed (i.e. osculating orbit at the epoch close to the observed perihelion passage), original and future orbits with their uncertainties and new orbital quality assessments, where as many as about 30% of them are non-gravitational orbits. These original and future orbits form a basis for independent, ongoing project focused on the origin of the near-parabolic comets, realized by Piotr A. Dybczyński from Poznań Observatory and me. Subsample of orbits of 38 Oort spike comets from the Warsaw Catalogue was investigated in the first part of other long-lasting project aimed at recalculation of orbits of all one-apparition comets discovered in the years 1901-1950.

Here, partial and the very preliminary results of the remaining one-apparition comets from the first half of the 19th century will be presented. Apart from 38 Oort spike comets, the sample consists of about 40 comets having original 1/a greater than 0.000100 au^{-1}, according to the latest edition of the Marsden and Williams Catalogue of Cometary Orbits (MWC), eight comets with orbits of quality class worse than 2 (original 1/a is not given in MWC in such cases) and 34 comets with parabolic orbits given in MWC (e=1 was assumed for these objects). New orbit recalculations generally give orbits of better quality, what is clearly visible within the subsample of the worst originally determined orbits. For at least half of the analysed comets from the 'parabolic sample' it turns out that their eccentricities: (i) are determinable at a comparable level of accuracy as eight orbits of class <2 and $e \neq 1$ in MWC, (ii) suggest that their aphelia lie within the inner Oort Cloud region.

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Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **17** Type: **Talk**

Anisotropic gas emission and non-uniform density distribution in a cometary coma

mercredi 18 mai 2016 17:00 (45 minutes)

In comets the anisotropic gas emission from their nuclei have been discovered in gas jets, fans, close-up images of cometary nuclei provided by missions, asymmetric shapes of the cometary gas production curves with respect to perihelion, asymmetric non-gravitational forces perturbing the cometary orbits and finally in the spectral imaging of comets in the molecular lines. The evidence of anisotropic outgassing of comets may be interpreted with models of non-uniform distribution of activity. The proposed axisymmetric model of the outgassing is based on (i) a non-uniform density distribution and (ii) the Couple Escape Probability (CEP) method for treating radiation transfer. The spatial and temporal distribution of activity depends on two different approach to the solar input. The enhanced gas flow related to the discrete active area is accompanied by some emission of uniformly distributed material. The gas density profile is described by a density function that vary as a function of the angle with respect to the outgassing axis. It is shown that the gas density distribution influences the absorption and emission signal in the line profile and its shape. Effects of the physical parameters of the cometary material like density, temperature, and expansion velocity on the line intensity are discussed. The synthetic line profiles and maps of water emission are constructed under assumption of various forms of the density function.

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Classification de Session: The physics of comets

Classification de thématique: The physics of comets

ID de Contribution: **19** Type: **Talk**

NUCLEUS AND ACTIVITY OF COMET 67P THROUGH THE EYES OF THE ROSETTA/OSIRIS CAMERAS

jeudi 19 mai 2016 10:00 (45 minutes)

Comets with their coma and tail are a spectacular sight on the night sky; they are important objects to understand the origin of our solar system. Comets are pristine and thus carry information on how they initially formed 4.5 billion years ago. 67P/Churyumov-Gerasimenko is the first comet studied in detail with a spacecraft in its vicinity for more than two years along the orbit around the sun.

Onboard the Rosetta spacecraft, the two scientific cameras, the OSIRIS narrow- and the wide-angle camera, are observing the cometary nucleus, its activity, as well as the dust and gas environment. The presentation will give an overview on what OSIRIS observed.

The scientific results reveal a nucleus with two lobes and varied morphology. Active regions are located at steep cliffs and collapsed pits which form collimated gas jets. Dust is accelerated by the gas, forming bright jet filaments and the large scale, diffuse coma of the comet.

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Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission

ID de Contribution: **20** Type: **Non spécifié**

Introduction

ID de Contribution: **21** Type: **Talk**

Probing the Oort Cloud with Centaurs

mardi 17 mai 2016 10:15 (45 minutes)

The Oort cloud has previously been invoked to explain observations of centaurs with very high inclinations and/or very large semimajor axes since such orbits are difficult to generate from the scattered disk. However, the known sample of centaurs has been detected with a combination of surveys with different observational biases, some more well-characterized than others. Consequently, it is difficult to compare the centaur production in numerical simulations with the orbital distribution of detected centaurs. Here we use the centaur sample of the Outer Solar Systems Origins Survey (OSSOS), along with a survey simulator, to determine if the Oort cloud is a significant source of centaurs. These results can provide additional constraints on the population and mass of the Oort Cloud.

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Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **22** Type: **Talk**

Oort Cloud evolution in a long-lived stellar cluster

mardi 17 mai 2016 16:45 (45 minutes)

Solar type stars typically form as members of embedded clusters, which dissolve on different time scales depending on their masses and densities. Most such clusters are small and short-lived, and Oort Cloud (OC) formation has often been modeled within such a scenario. But Lada & Lada (2003) showed that about equal numbers of stars are formed in clusters with populations of 10^2, 10^3 and 10^4 stars. This makes it likely that the Sun's birth cluster was more long-lived than assumed in OC formation models. We have investigated what happens to the intermediate and outer parts (in terms of semi-major axis) of OCs that form very early in such massive and long-lived clusters. Our results indicate that the survival of a full-fledged OC after the Sun's escape from this birth cluster depends critically on the existence of a massive inner core, comparable in size to the Sedna population.

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Orateur: RICKMAN, Hans (Uppsala University)

Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **23** Type: **Talk**

The role of comets in the Late Heavy Bombardment

jeudi 19 mai 2016 17:00 (45 minutes)

We have simulated the orbital evolution of icy planetesimals ("comets") in the inner solar system upon dispersal of the primordial planetesimal disk by giant planet migration as prescribed by the Nice Model. Using both the assumption of non-evolving comets and models including erosion by sublimation and splitting, we have estimated the impact rate and crater formation due to these comets on the Moon and terrestrial planets. From these simulations, assuming that this migration and its consequences caused the Late Heavy Bombardment (LHB), we conclude that the largest observed impact basins were likely not formed by comets, the smaller craters may or may not have an important cometary contribution, and the amounts of water delivered to the Earth and Mars by LHB comets were insignificant compared to the estimated total water inventories of those planets. These results are compatible with the suggestion by Bottke et al (2012) that the asteroidal E-belt was the main source of LHB projectiles.

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Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **24** Type: **Talk**

Surface properties of small icy bodies

mercredi 18 mai 2016 16:15 (45 minutes)

The study of the small bodies that orbit the Sun beyond Neptune, the transneptunian objects, has completely changed our view of the Solar System. The last decade, a huge quantity of data has been obtained by ground large telescopes and by space missions.
Various surface compounds have been detected, including ices of water, methane, nitrogen, methanol, ethane and ammonia. An overview for all available surface properties on TNOs and Centaurs will be presented analyzing the ice content with respect to the physical and dynamical characteristics. The last results on the asteroid (1) Ceres by DAWN mission will be also presented as well a comparison with the small icy bodies of the Solar System.

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Classification de Session: The physics of comets

Classification de thématique: The physics of comets

ID de Contribution: **25** Type: **Talk**

”Density and porosity of comet 67P/C-G constrained by its shape and rotation”

jeudi 19 mai 2016 15:00 (45 minutes)

Will be submitted soon

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Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission

ID de Contribution: **28** Type: **Talk**

On the existence of comet families in extrasolar planetary system

mercredi 18 mai 2016 11:15 (45 minutes)

We investigate whether there can exist comet families in the extrasolar planetary systems Kepler 90 and HD 10180, systems which consist of six planets; the outermost is a giant.
This is done by extensive numerical integrations of millions of hypothetical comets entering the inner system on almost hyperbolic orbits. The goal is to find whether
families like the Halley comets or the Jupiter comets can be captured. In addition the role of secular resonances to form such orbits of comets is investigated using analytical methods.

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Classification de Session: The dynamic of comets

Classification de thématique: The dynamic of comets

ID de Contribution: **29** Type: **Talk**

A study of the past dynamics of comet 67P/Churyumov-Gerasimenko with fast Lyapunov indicators

jeudi 19 mai 2016 16:15 (45 minutes)

On the basis of backward numerical integrations of a large set of simulated comets whose initial conditions were obtained from small variations of the orbital parameters of comet 67P, and using the analysis of suitable chaos indicators, we detect the phase–space structure of the past close encounters of the comet with Jupiter. On the basis of these computations we find that the probability that the comet could have been injected into the inner solar system from distances larger than 100 AU from the Sun in the past 150000 years is about 60 percent.

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Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission

ID de Contribution: **30** Type: **Talk**

Variations in cometary dust compositions from Giotto to Rosetta, clues to their formation mechanisms

jeudi 19 mai 2016 14:15 (45 minutes)

The composition of cometary dust has been measured by in situ and remote sensing instruments in the last decades, each analysis adding pieces to the puzzle of how and where comets formed. Giotto analyses of comet 1P/Halley dust particles have shown the presence of CHON and mixed particles. Astronomical observations showed that olivine and pyroxene are present in comets. Laboratory analyses of comet 81P/Wild 2 samples brought back by Stardust suggested the existence of a continuum between asteroids and comets. Some interplanetary dust particles and micrometeorites collected at the Earth surface could also have a cometary origin and constitute well preserved comet samples to be analyzed in the laboratory. We will present the implications of these results for the formation of cometary dust particles.

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Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission

ID de Contribution: **31** Type: **Talk**

Rosetta: the mission

jeudi 19 mai 2016 09:15 (45 minutes)

TBD

Author: FULCHIGNONI, Marcello

Orateur: FULCHIGNONI, Marcello

Classification de Session: The Rosetta Mission

Classification de thématique: The Rosetta mission