13 AUGUST 2015

ASTROCHEMISTRY LETTERS

Astrochem. Soc. Ind.

ISSUE 2

PERIHELION APPROACH OF COMET 67P/CG CARRYING PHILAE

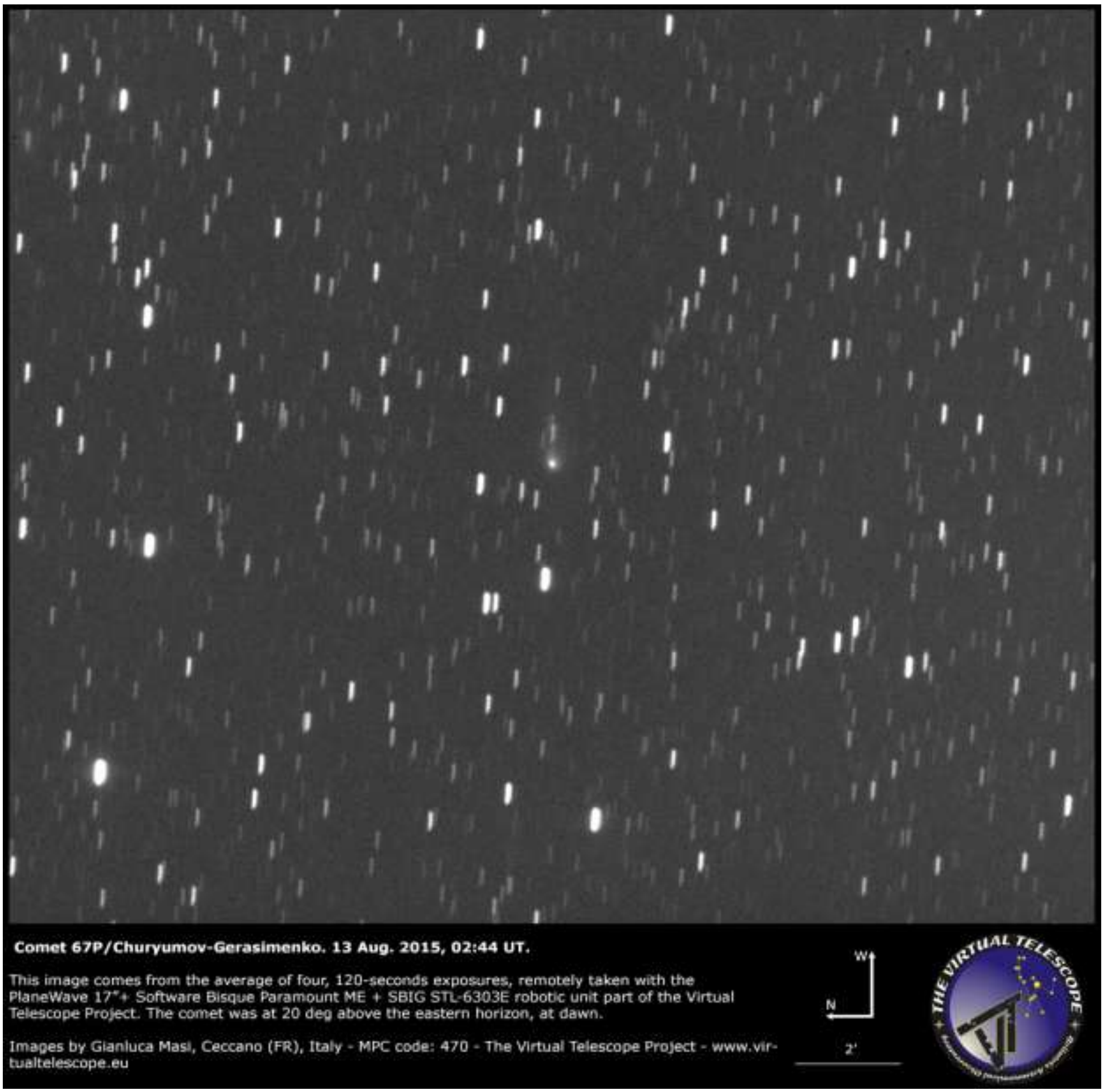


Image Description: Post-perihelion image of comet 67P/C-G taken by PACA member and Director of The Virtual Telescope, Dr. Gianluca Masi on 13th August 2015, at 02:44:13 UT.

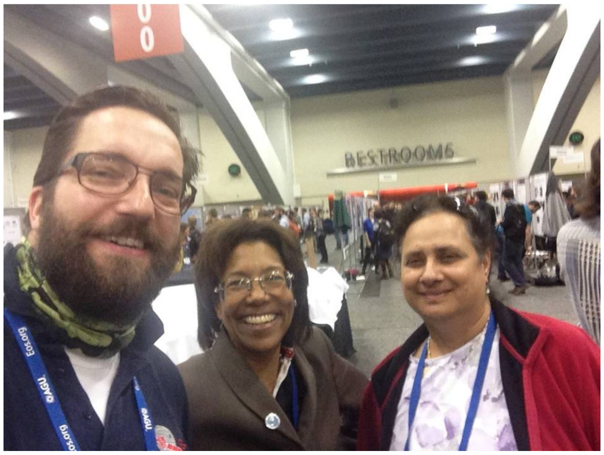
CONTENTS

Claudia J. Alexander (1959 - 2015)

Dr. Padma A. Yanamandra-Fisher, *Space Science Institute, Boulder, Colorado, USA.*

Comet 67P/Churyumov-Gerasimenko (CG), the final target of ESA mission Rosetta, was also the pinnacle of Dr. Claudia Alexanders extraordinary professional achievements. She lost her battle with breast cancer on 11 July 2015 and left behind a wonderful and multi-faceted legacy from students to scientists. Although journalism was first choice for study, Claudia chose science as a compromise with her parents to attend school in California. With impressive credentials such as undergraduate degree from University of California, Berkeley; masters from University of California, Los Angeles (UCLA), Ph.D. from University of Michigan, Claudia was employed at NASA/Jet Propulsion Laboratory (JPL), as an engineer for NASA/Galileo mission to Jupiter. As she rose in her career at JPL, Claudia served as the last Project Scientist for Galileo mission, as the spacecraft was allowed to crash into the planet, Jupiter; served on NASA/ESA/Cassini mission to Saturn; and finally the US NASA Project Scientist for ESA/Rosetta mission to comet 67P/CG via several asteroid fly-bys. Claudia was always seeking to improve various procedures to enhance performance of the mission. Claudia was interested in the application and use of both social media and amateur astronomers in support of ESA/Rosetta mission to comet 67P/CG and instrumental for my role as US Rosetta Collaborator for Global Amateur Observations of Comet 67P since 2014. Thanks to her support and confidence (and supported by ESA/Rosetta Project Scientist, Dr. Matt Taylor), a global community of amateur observers was created on several social media, including Facebook, Flickr, Twitter, etc., with a joint JPL call for participation. At last count, nearly 250 amateur observers have signed up to participate in the 67P observing campaign!

On a personal level, Claudia was a remarkable, multi-faceted person; determined to achieve success, as a black woman in a field where there were few and a strong advocate for many important causes: from STEM-related causes to the inclusion of indigenous peoples (such as Native American and Hawaiian) to help broaden their languages to include astronomy in a balance with their cultural heritage. Claudia was a great writer, with several successful childrens books, with the latest book released recently. Claudia also was a strong advocate to ensure, as Project Scientist, there were proper and adequate resources for the US Teams for ESA/Rosetta mission to allow the US Teams to provide the required work products for the ESA/Rosetta mission. She had a vision of how to integrate and enhance the various components of such a large and ambitious mission and empower people to produce their best.



ESA/Rosetta Project Scientist, Matt Taylor (left), US Project Scientist for Rosetta, Claudia Alexander (center) and the authour, Padma A. Yanamandra-Fisher (right) at the 2014 American Geophysical Union (AGU) meeting in San Francisco, CA, USA.

Besides science, Claudia enjoyed life with her devotion to her family she was unmarried, but her family of parents, siblings, nieces and nephews was her solid foundation. With interests from dancing, writing, horse riding, tennis (she enjoyed watching Roger Federer) and journalism, Claudia had multi-circles of friends in all these fields. She impacted and left a legacy of knowledge, role models, and various activities to promote STEM-literacy amongst young girls.

Claudia Alexander was a true trailblazer for many generations to come. I hope she is watching from the heavens as comet 67P/CG goes through perihelion on 13 August 2015, with ESA/Rosetta spacecraft in orbit around the comet.

On the Difficulty of Finding New and Complex Molecules in Comets

Dr. Michael J. Mumma, *NASA Gaddard Space Flight Center,USA*

Almost from the moment in 1970 when I first was exposed to discussions on the chemistry of comets, talk turned to methods for detecting the expected parent volatiles that could explain the observed free radical species seen in cometary comae (OH, CN, C_2, C_3, CO^+, etc.), and to the possible astrochemical implications of the native ices in cometary nuclei from which they derived. During the decadal 70s, I was strongly influenced by extended and continuing discussions with Armand Delsemme, Bertram Donn, William M. Jackson, and Fred Whipple during our attempts to define and achieve in situ exploration of comets, and through laboratory investigations to understand the molecular processes that might control their properties.

Fred Whipple envisioned the cometary nucleus as an icy conglomerate composed of refractory (meteoritic) dust and native (primary) ices, whose sublimation upon warming created the visible coma and tails so familiar to ground-based observers (Whipple 1950). In so doing, he adopted and extended Pol Swings suggestion that the nucleus of comet Encke contained polyatomic molecular ices, whose release and dissociation produced the free radical species observed at optical wavelengths (Swings 1948a, 1948b). Whipple and Swings suggested that the polyatomic molecules stored in the nucleus were of interstellar origin, and thus of primary importance for understanding planetary origins. Whipple further proposed that water ice was dominant, with ices of methane, ammonia, and other species present in smaller amounts.

Whipples proposal triggered a decades-long effort to detect the proposed primary (parent) volatiles through astrophysical spectroscopy that in 1985 produced the first definite detections of primary volatiles in a cometary coma: hydrogen cyanide and water vapor were detected in comet 1P/Halley using ground-based radio and airborne infrared observatories (HCN: Despois et al. 1986, Schloerb et al. 1986; H_2O: Mumma et al. 1986, Weaver et al. 1986). In 1986, in situ spacecraft measurements confirmed these discoveries, added ten more species to the suite of known primary volatiles, and acquired images of a cometary nucleus for the first time (Praderie Grewing 1987, Eberhardt 1999). The combined results decisively confirmed the Whipple-Swings model of the icy conglomerate nucleus.

Today, we recognize that the composition of cometary ices can sometimes reflect changes induced by thermal and radiation processing, so their identities and abundances can provide central clues to those aspects of planetary heritage. Yet, extending the ground-based detections of cometary H_2O and HCN to more complex species has proven difficult and was/is strongly dependent on advances in both theoretical and observational capabilities. I will use my own experience as an example, keeping in mind that my experiences are certainly not unique in struggling to achieve new ends.

My initial foray was an attempt to detect infrared emission from NH_3 (2, 10 microns band) in comet C/1973x Kohoutek, using a laser heterodyne spectrometer that utilized a then-developmental lead-salt laser as a local oscillator. Working day and night for 3 months, my team built the spectrometer, mated it to a telescope, and acquired astronomical data but the comet fizzled and ammonia could not be detected (Mumma et al. 1975). We next decided to use CO_2 lasers as local oscillators, building our own since commercial devices were not well suited to astrophysical needs. After perfecting the spectrometer, in 1976 we emplaced it at the McMath Telescope at Kitt Peak National Observatory, and then in 1981 moved it to the NASA IRTF on Mauna Kea. During this period, we studied CO_2 non-thermal emission on Mars and Venus, trace gases in Earths atmosphere, and NH_3 in stellar atmospheres and in Jupiter.

We searched for NH_3 whenever a suitable target comet appeared, but repeated failures showed that our approach was fundamentally flawed. Our stellar work revealed that the gases there were rotationally relaxed but vibrationally hot, owing to the collisionally impoverished low-density atmosphere. The eureka moment came when I realized that the cometary atmosphere was both very cold and collisionally impoverished, suggesting that radiative decay from solar-pumped excited states would compete favorably against collisional quenching, thereby permitting intense ro-vibrational emission lines characterized by low rotational temperatures. The optimum wavelength domain for detections would also depend on the specifics of the process and the molecule in question. I immediately embarked on intense consideration of the physics involved, and presented first thoughts at a conference in 1981 (Mumma 1982). Hal Weaver joined me as a post-doctoral fellow that year, and our greatly expanded version of this idea was submitted for publication on 8 March and accepted on 28 June 1983 (Weaver and Mumma 1984). Our models assumed fluorescence equilibrium. Unknown to us, Crovisier and Encrenaz were developing the idea in parallel, but they emphasized LTE rotational populations at 300K so then-available molecular databases could be used for simulations; their paper was submitted on 12 March and accepted on 26 April 1983 (Crovisier and Encrenaz 1983). These two papers form the basis for the now-widely accepted observational approach of solar-pumped infrared fluorescence, for detection of primary volatiles in comets. Many subsequent papers established the methodology for vibrational band systems of molecules having up to 8 atoms (C_2H_6).

This work demonstrated that the prime wavelength region for ground-based detections was in the near infrared (3-5 micron), not the mid-infrared as first conceived. It further showed that high spectral resolution was needed, and that a Doppler shift (to avoid extinction) was needed for volatiles that had terrestrial counterparts. Moreover, only low rotational temperatures were expected. Together, these constraints drove the initial search strategies, leading to detection of water (the 2.7 micron fundamental band, 3) in comet 1P/Halley using the University of Arizonas infrared Fourier Transform Spectrometer (FTS) on NASA's Kuiper Airborne Observatory, on 22 and 24 December 1985. Water detections followed in comets C/1987 P1 (Wilson) (in 1987) and 23P/Brorsen-Metcalf (in 1989), but a new approach was mandated by sensitivity needs. The team attempted detections of methane in comets Halley and Wilson, without success, and the large optical bandwidth of the FTS presented large stochastic noise to the detection system. However, the airborne detections of water vapor in three comets confirmed the theoretical predictions of solar-pumped infrared fluorescence from primary volatiles, and the importance of high resolution spectroscopy for detecting them.

Even before 1986, it was clear that grating spectroscopy with array detectors offered a possible solution to the sensitivity question. In 1987, these instruments were barely emerging, and the first was commissioned at the NASA IRTF on Mauna Kea, Hawaii. CGAS featured a simple 32 element linear array behind a cryogenic grating that narrowed the optical bandwidth per pixel, thereby reducing shot noise from the optical background dramatically. The first proposed use for cometary detections was proposed independently by two teams that then merged for a Target-of-Opportunity campaign on C/1987 P1 (Bradfield) (Brooke et al. 1990). By 1989, 2-D array-based (58x62 and 128x128) cryogenic grating spectrometers were available at KPNO and UKIRT, and my Team extended the CGAS findings to other comets with these more powerful instruments. We also teamed with John Lacys team to search for OCS and CO near 4.7 and 5.0 m in comets C/1990 Levy (DiSanti et al. 1992).

After 1992, ground-based capabilities expanded rapidly. CSHELL at IRTF enabled a major breakthrough by coupling high resolving power with a 256x256 array detector. With CSHELL, my team detected an emission line of H_2O near 2 micron in C/1991 T2 (Shoemaker-Levy). CSHELLs upgrade to an InSb detector array in 1995 permitted detection of H_2O in comet 6P/dArrest (Mumma et al. 1995). These detections of H_2O emission in two comets were the first definite detections of cometary water from ground-based observatories.

The planned de-commissioning of the KAO in 1995 emphasized the critical need to develop a new method for detecting cometary water from ground-based observatories. The problem can be stated succinctly: how can we make Earths atmospheric water disappear, so as not to absorb the water lines emitted by an extraterrestrial source. The successful strategy seems obvious once explained and so it is but it was not so obvious before the strategy was conceived, and then demonstrated!

The breakthrough was dependent on recognizing that fluorescent emission from solar-pumped excited quantum states could penetrate to the ground if the transition terminated on an excited rovibrational level that was not populated at atmospheric temperatures. It was rooted in the discovery of hot-band emission in 1P/Halley that was identified in spectra acquired on the KAO; 3 unidentified emission lines were seen in March 1986. I had brought a copy of the H_2O spectral atlas of Flaud Camy-Peyret to New Zealand for the March flights, and searched the atlas for these lines. Comparison of the new lines revealed that they belonged to the 3 011-010 hot band that emitted in the 2.7 micron region. Several years later when considering ways to make terrestrial water vapor disappear, I realized that fluorescent transitions that terminated on more highly excited states would be transmitted to the ground, permitting detection of H2O from ground-based observatories.

In 1990, Michael DiSanti (then my postdoctoral associate) and I considered possible band systems and identified the 111-100 hot-band near 2.0 micron as a favorable candidate. In 1992, we targeted its detection in C/1991 A1 (Shoemaker-Levy) with CSHELL/IRTF and in 1995 targeted it in 6P/d'Arrest - detecting water in these two comets confirmed the strategy. In 1996, we targeted water in newly discovered C/1996 B2 Hyakutake, detecting many lines of this band and using the resulting water production rate as the comparator for trace gases CO, CH_4, HCN and C_2H_6 detected in this comet (Mumma et al. 1996; Dello Russo et al 2002). Since then this approach has been extended to more than 10 water hot bands that span the 1-5 m region, providing a means to quantify the dominant volatile in comets simultaneously with individual trace species. CSHELL also cleared the path for detections of many primary volatiles in comets Hyakutake and C/1995 O1 (Hale-Bopp) at 3-5 micron (L- and M-bands). In 1999, we extended the strategy to prompt emission of highly excited OH produced by water photolysis (an outgrowth of my Ph.D. dissertation on dissociative excitation of small molecules) and later comets providing a second approach for direct measurements of water in comets.

CSHELL reigned supreme until 1999, when NIRSPEC at Keck-2 was commissioned - the first cryogenic cross-dispersed high resolution grating spectrometer at a high altitude site. During the commissioning run, 7 primary volatiles and OH* (prompt emission) were detected in C/1999 H1 (Lee) (Mumma et al. 2001). Up to 12 primary volatiles have been detected in a given comet with NIRSPEC, and all simultaneously with water. Subsequent instrumental advances included higher resolving power (80,000) and the use of four 1K x 1K InSb arrays (CRIRES/VLT) (but single spectral order) and the imminent commissioning of iSHELL/IRTF, equipped with a Hawaii-2RG HgCdTe 2K x 2K detector array, cross-dispersion, and ultra high spectral resolution (approx 80,000). An upgrade for CRIRES is now in progress that will provide similar capability for VLT, with cross-dispersion and with three 2K x 2K Hawaii-2RG detector arrays. These facilities will provide higher sensitivity, greater spectral grasp, and improved specificity (higher spectral resolving power), and will enable detections of new and more complex volatile species, along woth isotopologues of the more abundant species.

The ever higher spectral resolving power (now approaching resolution of 3 km/s) required similar expansion of laboratory data on molecular band systems, along with advanced quantum mechanical band models hundreds of papers have reported these new findings and their application to fluorescence models for comets and other astrophysical sources.

Today, many primary volatile are measured routinely in a moderately active comet (cf. Mumma and Charnley 2011). Improvements in sensitivity now permit measurement of primary volatiles at abundances as small as 100 ppm (relative to H_2O). To date, more than 20 comets have been characterized in this way, and we now can build an emerging taxonomy based on cosmogonic parameters such as composition, isotopic fractionation, and nuclear spin temperatures of primary volatiles, along with dust signatures such as crystallinity and mineralogy. The number of detected species has advanced as the observational capabilities expanded (Figure 1), and is even now undergoing a revolution with the emergence of IRAM-EMIR and ALMA at radio wavelengths, and of next-generation powerful high resolution cryogenic spectrometers at infrared wavelengths (iSHELL/IRTF and CRIRES+/VLT). This trend will expand with the commissioning of iSHELL/IRTF, CRIRES+/VLT, and the near IR high resolution and massively parallel spectrometers at 30-m class telescopes (E-ELT, TMT, GMT).

While local processing can affect the abundance ratio of bulk species in comets, the abundance ratios of isotopologues are more robust because few mechanisms exist to modify one isotopologue more efficiently than another within the nucleus. For this reason, D/H in water and HCN, 14N/15N in nitriles (CN and HCN), and 12C/13C in organics (CN and C_2) have assumed high importance. Compared with terrestrial values, cometary values for 12C/13C are consistent in CN and C_2, but 14N/15N is much lower in CN (15N is enriched), and D/H varies strongly in water and hydrogen cyanide. Most comets show water more enriched in deuterium compared with Earths oceans, but the enrichment in 103P/Hartley 2 was exactly consistent with that in ocean water (VSMOW), showing that comets of this type could have contributed water to Earth.

m

However, care must be taken when interpreting such limited measurements, especially when the context is unknown. For example, ROSINA reported the D/H ratio in coma water to be enriched to 3 VSMOW while 67P/Churyumov-Gerasimenko was still far from the Sun (3.7 AU), where water is not yet fully activated (Altwegg et al. 2015). The surface layer was likely enriched in HDO by fractionation of water emplaced during the last retreat from perihelion (the vapor pressure of HDO is lower than that of H_2O), and so an enriched value should be seen as the comet becomes active again on its next return to perihelion. The test will come when water is fully activated and both isotopologues are subliming fully, perhaps during the near-perihelion passage. The emerging compositional and isotopic taxonomies are crucial for extrapolating in-depth analytical information obtained from the few comets sampled directly, such as 67P, to the many that are sampled only remotely.

The composition and structure of cometary nuclei hold vital clues to understanding the formation and evolution of matter in the early Solar System (Mumma, Weissman Stern 1993; Irvine et al. 2000; Bockele-Morvan et al. 2004; Mumma and Charnley 2011). Relating the sampled comets to the diverse populations of icy planetesimals is a critical step when testing models of the evolution of material from the natal interstellar cloud core through entry into the protoplanetary disk, possible processing in the disk, formation of the nal icy bodies, and injection into their cosmic reservoirs. With the aid of dynamical models, the emerging taxonomies will also help to assess the signicance of each cometary class for exogenous delivery of organics and water to terrestrial planets.

References

Altwegg, K., H. Balsiger, A. Bar-Nun, J. J. Berthelier, A. Bieler, P. Bochsler, C. Briois, U. Calmonte, M. Combi, J. De Keyser, P. Eberhardt, B. Fiethe, S. Fuselier, S. Gasc, T. I. Gombosi, K.C. Hansen, M. Hssig, A. Jckel, E. Kopp, A. Korth, L. LeRoy, U. Mall, B. Marty, O. Mousis, E. Neefs, T. Owen, H. Rme, M. Rubin, T. Smon, C.-Y. Tzou, H. Waite, P. Wurz, 2015. *67P/Churyumov-Gerasimenko, a Jupiter family comet with a high D/H ratio.* Science 347, 1261952 (3pp). doi:10.1126/science.1261952.

Bockelee-Morvan, D., J. Crovisier, M. J. Mumma, and H. A. Weaver 2004, "The Composition of Cometary Volatiles." D. Bockelee-Morvan, J. Crovisier, M. J. Mumma, and H. A. Weaver, in Comets II, Univ. of Ariz. Press, eds. M. Festou, H. U. Keller, and H. A. Weaver, pp. 391-423. Brooke, T., A. Tokunaga, R. Knacke, T. C. Owen, M. J. Mumma, D. Reuter, and A. Storrs 1990, *"Detection of the 2.8 m and 3.4 m Emission Features in Comet Bradfield (1987s)",* Icarus 83, 434-440.

Crovisier, J. and Encrenaz, T. 1983. *Infrared fluorescence of molecules in comets - The general synthetic spectrum,* Astron. Astrophys. 126:170-182.

Dello Russo, N., M. J. Mumma, M. A. DiSanti, and K. Magee-Sauer 2002, *"Production of ethane and water in comet C/1996 B2 Hyakutake."* J. Geophys. Res. 107, No. E11, CiteID 5095. doi:10.1029/2001JE001838.

Despois D, Crovisier J, Bockele-Morvan D, Schraml J, Forveille T, Gerard E. 1986. *Observations of hydrogen cyanide in Comet Halley.* Astron. Astrophys. 160: L11-12.

Eberhardt P 1999. *Comet Halley's gas composition and extended sources: Results from the neutral mass spectrometer on Giotto.* Sp. Sci. Rev. 90:45-52.

Irvine, W.F., F. P. Schloerb, J. Crovisier, B. Fegley, and M. J. Mumma 2000 *"Comets: A link between Interstellar and Nebular chemistry."* in Protostars and Planets IV, eds. V. Mannings, A. P. Boss, and S. S. Russell, (Univ. of Ariz. Press, Tucson) pp. 1159 - 1200.

Larson, H. P., H. A. Weaver, M. J. Mumma, and S. Drapatz 1989, *"Airborne Infrared Spectroscopy of Comet Wilson 1986l and Comparisons with Comet Halley",* Ap. J. 338, 1106-1114.

Mumma, M. J. and S. B. Charnley 2011, *The Chemical Composition of Comets Emerging Taxonomies and Natal Heritage.* Ann. Rev. Astron. Astrophys. 49:471-524.

Mumma, M. J. 1982, *"Speculations on the Infrared Molecular Spectra of Comets",* M. J. Mumma, in Vibrational Rotational Spectroscopy for Planetary Atmospheres", NASA CP-2223, p. 717-742.

Mumma, M. J., I. S. McLean, M. A. DiSanti, J. E. Larkin, N. Dello Russo, K. Magee-Sauer, E. E. Becklin, T. Bida, F. Chaffee, A. R. Conrad, D. F. Figer, A. M. Gilbert, J. R. Graham, N. A. Levenson, R. E. Novak, D. C. Reuter, H. I. Teplitz, M. K. Wilcox, and Li-Hong Xu 2001, *A survey of organic volatiles and dust in comet C/1999 H1 (Lee) with NIRSPEC at the Keck Observatory,* Ap. J. 546:1183 - 1193.

Mumma, M. J., M. A. DiSanti, A. Tokunaga, E. E. Roettger 1995, *"Ground-based detection of water in Comets Shoemaker-Levy 1992 XIX and 6P/d'Arrest: Probing parent volatiles by hot-band fluorescence",* Bull. Amer. Astron. Soc. 27, No. 3: 1144.

Mumma, M. J., M. A. DiSanti, N. Dello Russo, M. Fomenkova, K. Magee-Sauer, C. D. Kaminski, and D. X. Xie 1996, *"Detection of Abundant Ethane and Methane, along with Carbon Monoxide and Water, in Comet C/1996 B2 Hyakutake: Evidence for Interstellar Ice",* Science 272, No. 5266: 1310-1314.

Mumma, M. J., P. R. Weissmann, and S. A. Stern 1993, *"Comets and the Origin of the Solar System: Reading the Rosetta Stone",* in Protostars and Planets III, Univ. of Ariz. Press, pp. 1172-1265.

Mumma, M. J., T. Kostiuk, S. Cohen, D. Buhl, and P. C. von Thuna 1975, *"Infrared Heterodyne Spectroscopy of Astronomical and Laboratory Sources at 8.5 m",* Nature, 253, 514-516.

Praderie F, Grewing M. 1987. *Halleys Comet.* Astron. Astrophys. 230:1-936

Schloerb FP, Kinzel WM, Swade DA, Irvine WM. 1986. *HCN production from comet Halley.* Ap. J. 310:L55-60
Swings P 1948a. Le spectre de la Comte DEncke, 1947i. Ann. Astrophys. 11:124-36

Swings P 1948b. *La physicochimie des Comtes.* Ciel et Terre 64:16-27

Weaver, H. A., and M. J. Mumma 1984,*"Infrared Molecular Emissions from Comets",* Ap. J. 276, 782-797.

Weaver, H. A., M. J. Mumma, H. P. Larson, and D. Scott Davis 1986, *"Post-Perihelion Observations of Water in Comet Halley",* Nature 324, 441-446.

Whipple FL 1950. *A comet model I: The acceleration of comet Encke.* Ap. J. 111:375-94

Rosetta: Perihelion approach and Beyond

Dr. Matt Taylor, *Scientific Support Office, Rosetta Mission*

A lot has happened in the world of Rosetta in the last months. We have been orbiting the Sun along side Comet Churyumov Gerasimenko for a year and on 13th August we will reach perihelion.

In the last year we have become more and more familiar with out target, a dual lobed comet, which we affectionately refer to as duck-shaped. This frozen body of dust and ices is around 4 km across and its outer atmosphere or coma currently stretches well over 100, 000 km into a tail, based on estimations from ground based observations. Ground based observations are very important to Rosetta, and on top of professional observations, we have a very active amateur connection, coordinated by Padma A. Yanamandra-Fisher a Senior Research Scientist at the Space Science Institute, USA.

On 11 July Rosetta lost a dear colleague, Dr Claudia Alexander, the US project scientist who passed away suddenly. Claudia worked for NASA at JPL. She was an eminent planetary scientist and was deeply involved with the Rosetta Mission as US Rosetta project scientist. She was passionate about outreach, including engaging amateur astronomers through the ground-based observing campaign of Rosettas target comet, 67P/ChuryumovGerasimenko. Claudia was also very well known for her role in NASAs Galileo and Cassini projects. She will be greatly missed. Last month you heard from Alan Stern and New Horizons. We have some connection there, as Alan is Rosetta colleague also as PI of the Alice instrument. In fact, we actually pointed Rosetta at Pluto when New Horizons was doing its fly by!

In July, we released the first results of Philae, from the surface of the comet. The results indicated the surface of the comet to by covered by a thin dust layer with a very hard subsurface. We detected a number of organics molecules, some of which are key in playing a role in pre-biotic synthesis of amino acids, sugars and nuclebases: the ingredients of life. It is important to stress that we do not see life itself though. Only the building blocks. The existence of such complex molecules in a comet, a relic of the early Solar System, imply that chemical processes at work during that time could have played a key role in fostering the formation of prebiotic material. We found little evidence of an intrinsic magnetic field indicating that magnetic field would have had little role to play in the aggregation processes as the comet was formed. We are beginning to see significant activity at the comet, so Perihelion is going to be an exciting time., as one can see from recent images.

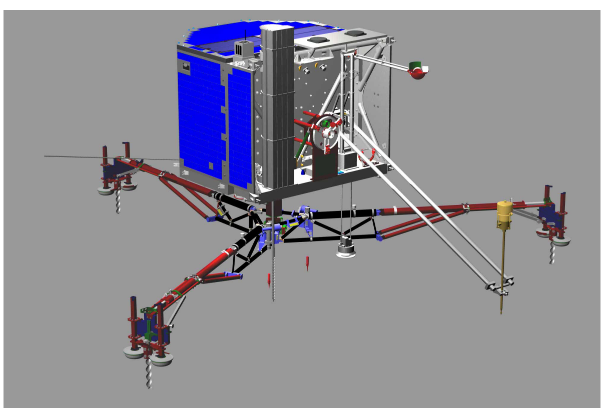
Following this month, the mission will continue through to September 2016, where we will de-orbit the Rosetta spacecraft into the comet, landing for a 4th time!

Rosetta Lander Philae: First Data from the surface of a Comet

Dr. Stephan Ulamec, *German Aerospace Center, DLR, 51147 Cologne.*

November 12th, 2014, when Philae landed on comet 67P/Churyumov-Gerasimenko, this was the first time in history, when in-situ investigation of a cometary nucleus became possible.

Comets are believed to be 'left overs' from the time of the formation of the solar system, about 4,6 billion years ago. In addition they are believed to contain organic material, possibly triggering the formation of life on Earth.



CAD model of the Philae Lander, with instruments deployed

Philae is part of the ESA (European Space Agency) Rosetta mission, and was provided by an international consortium, led by the German Aerospace Center, DLR, with large contributions from MPS, CNES, ASI and other partners. It was attached to the mother spacecraft during its ten years of cruise. Only, when Rosetta arrived at the target comet, in August 2014, it became possible to characterize the nucleus with orbiter instruments and to select an appropriate landing site.

The Lander was separated from Rosetta at an altitude of about 22 km and touched ground after seven hours of ballistic descent. It was intended to be anchored by two harpoons, but, unfortunately those failed to fire, so Philae was bouncing off and landed after several ground contacts about 1km from the original site in an area now called 'Abydos'

Scientific data were gained during descent, the bounces and at Abydos. All of the ten scientific instruments aboard the Lander could be operated at least once, until the batteries depleted after about 64 hours after separation. Unfortunately, Philae is now at a spot which is poorly illuminated and after the first scientific sequence in November, it took eight months till 67P (and Philae) were close enough to the sun, and the Lander could again establish radio contact with the mother spacecraft.

The terrain is characterized by rough rock-like structures. (Note that the material is not expected to be rock, but sintered, porous ice-dust agglomerate with high organic content.) The instrument MUPUS, attempting to hammer a penetrator into ground indicated a surprisingly high crushing strength of at least 4MPa!

Two mass spectrometers on board the Lander, COSAC and Ptolemy, delivered spectra immediately after the first touch-down. While COSAC identified 16 molecule species, including amines, amides and alcohols (some of which are of prebiotic relevance), Ptolemy found clear indication for organic polymers in the cometary material.

CONSERT, a radar tomographer allowed insight into the global internal structure of the comet nucleus, indicating a rather homogeneous interior, with a permittivity of $\in = 1.27$ corresponding to a porosity of 75 to 85 percent.

ROMAP, a fluxgate magnetometer identified a lack of remnant magnetization of the comet surface, which is interpreted that there was no significant magnetic field in the planetary disc, when 67P formed.

The camera ROLIS, looking 'downward' provided fascinating images of the first touch-down site with a resolution op to 1cm. The terrain is characterized by coarse regolith and embedded boulder-like features.

The teams will continue to work on possibilities to command Philae, so that more scientific data can be obtained until the heliocentric distance will become too large again to power the Lander (probably end October 2015).

Philae provided unique science on structure and composition of a cometary nucleus. Part of these results will enhance the planning for future missions to comets, particularly those foreseeing landing or sampling.

References

J. Biele et al., *The landing(s) of Philae and inferences on comet surface mechanical properties.* Science 349, aaa9816 (2015).

S. Ulamec, et al., *Rosetta Lander Philae: landing preparations,* Acta Astron. 107, (2015).

J.-P. Bibring et al., *67P/Churyumov-Gerasimenko surface properties as derived from CIVA panoramic images. Science, 349, aab0671 (2015).*

T. Spohn et al., *Thermal and mechanical properties of the near-surface layers of comet 67P/Churyumov-Gerasimenko.* Science 349, aab0464 (2015).

F. Goesmann et al., *Organic compounds on comet 67P/Churyumov-Gerasimenko revealed by COSAC mass spectrometry.* Science 349, aab0689 (2015).

P. Wright et al., *CHO-bearing organic compounds at the surface of 67PChuryumov-Gerasimenko revealed by Ptolemy.*Science 349, aab0673 (2015).

W. Kofman et al., *Properties of the 67P/Churyumov-Gerasimenko interior revealed by CONSERT radar.* Science, 349, aab0639 (2015)

H.-U. Auster et al., *The nonmagnetic nucleus of comet 67P/Churyumov-Gerasimenko.* Science 349, aaa5102 (2015).

S. Mottola et al., *The structure of the regolith on 67P/Churyumov-Gerasimenko from ROLIS descent imaging.* Science 349, aab0232 (2015).

PACA Rosetta67P: Leveraging Amateur Astronomers and Social Media in Support of ESA/Rosetta Mission to Comet 67P/Churyumov-Gerasimenko (CG)

Dr. Padma A. Yanamandra-Fisher, *Space Science Institute, California, USA.*

Rosetta Mission to Comet 67P/CG and Need for Ground-based Observational Support:

The European Space Agency (ESA) Rosetta mission (with 18 European partners and NASA), launched in 2004, is an ambitious engineering and science mission. The spacecraft consists of an orbiter (Rosetta) and lander (Philae), with a combined suite of 21 instruments to rendezvous with a comet, drop a lander on the comet to study it in situ, orbit the comet and escort it into the inner solar system to its perihelion, all the while learning about the composition, the initiation and sustaining of activity of the comet. After encountering two asteroids, an earth swing-by, the Rosetta spacecraft exit from a near-3 year hibernation on 20 January 2014 to resume its journey to its final destination, comet 67P/Churyumov-Gerasimenko (67P). The key milestones for the mission are: (a) encounter with its final target, comet 67P/Churyumov-Gerasimenko (or 67P), in May 2014; (b) orbit insertion in August 2014 and mapping of 67P; (c) release of lander, Philae, in November 2014; and (d) escort 67P on its journey to perihelion in August 2015. The target for the Rosetta mission, 67P/Churyumov-Gerasimenko (67P), discovered by Klim Churyumov and Svetlana Gerasimenko in 1969, is a short-period comet, low orbital inclination, and influenced by Jupiters gravity field. Such comets are know as Jupiter Family comets (JFC) and considered to originate in the Kuiper Belt, just outside the orbit of Neptune. Since its discovery in 1969, the comet has been observed on six apparitions, with an orbit of 6.45 years. From past apparitions, it is known that the comet becomes active about a month before perihelion, with at least three active jets and a long tail that persists months after its perihelion passage seasonal changes of the comet. Rosettas close-up views of the comet nucleus and the observations of the initiation of the comets activity indicate the nucleus is bi-lobed or rubber ducky shaped, very dark and has an orbital period of 12 hours; with the narrow/neck part of the nucleus exhibiting the first jet activity was observed. Global observations from Earth are still necessary, to compare with previous apparitions and relate observed changes with the varying activity level. Therefore, the Rosetta mission sought ground-based observational support from both professional and amateur astronomers worldwide. The advantages of professional facilities allows the use of large telescopes to be able to acquire data of the comet; however, since the comet is expected to be faint (around magnitude 12) even at closest approach, a dedicated global international network of amateur astronomers is necessary to be able to observe the comet whenever it is available at their particular location and build a temporal and spatial data base of observations. The ground-based observations consist of two networks: (i) professional observers and (ii) amateur astronomers, each with a coordinator, to ensure the best observations are acquired in support of the mission and to liase with the mission science teams. As part of the support for ESA/Rosetta mission, a complementary two-pronged ground-based observational program was initiated late 2013: a professional observer component, overseen by Dr. Colin Snodgrass, Open University, England and an amateur observer component, overseen by Dr. Padma A. Yanamandra-Fisher, Space Science Institute, USA. As Global coordinator for amateur observations, Dr. Yanamandra-Fisher initiated a core network of amateur observers, based on the legacy of her work with the NASA/CIOC and the equivalent social, amateur observer networks for Comets C/2012 S1 (ISON) and C/2013 R1 (Siding Spring). The resulting network of observers is the basis of the Facebook group, PACA Rosetta67P, including members of the media, educators, Rosetta mission managers and team members in addition to the observer network. Formed in January 2014, the observer network has imaged comet 67P/CG from March 2014, when the comet was just detectable by amateurs, at a magnitude of 19-20 and available in the southern latitudes, with Peter Lake, of iTelescope.net in Siding Spring, Australia, being one of the first observers. Since then, regular contributions by other PACA observers such as Efrain Morales (Puerto Rico, USA), Andres Chapman (Argentina, South America), Rolando Ligustri (Italy), have formed the basic timeline of the comets changing magnitude with time or its light curve. As the comet became available at other latitudes, other PACA members/imagers have joined the campaign, with observers as far north as Essex, England (Dave Eagle, Peter Carson, Nick James) contributing data.

Leveraging Amateurs and Social Media:

The availability and access to various forms of social media with the immediate dissemination of observations and results, while being able to engage with other professional and amateur colleagues globally. Perceiving a need for an organized connection between the Pro-Am observer communities, I created The PACA Project from my earlier Pro-Am efforts in support of NASA Comet Observing campaigns (CIOC) for comets C/2012 S1 (ISON) in 2013, which dramatically disintegrated on its perihelion day of 28 November 2013 and C/2014 A1 (Siding Spring), which flew by very close to Mars on 19 October 2014. Currently, The PACA Project is involved in the Ground-based Amateur campaign to observer ESA/Rosetta missions target, 67P/Churyumov-Gerasimenko (CG) that is en route to its perihelion on 13 August 2015. Since the formation of its Facebook group, PACA Rosetta67P, in January 2014, the group consists of a core group of amateur astronomers, (their locations shown as red dots in Figure 1), professional observers and members of the mission teams, including the two project scientists (Drs. Matt Taylor/ESA and Claudia Alexander/NASA/JPL).

The various social media, creative logos, bookmarks illustrating the Egyptian theme used by Rosetta to name the various regions of the comet nucleus and the landing site for Philae lander; and appropriate QR codes relating to the social media are shown, created by various members of the Facebook group, PACA Rosetta67P.

JPL/PACA Call for Participation:

Since November 2014, the comet was behind the sun or conjunction, and therefore not visible to observers on ground. Following the first recovery detection of the comet of magnitude 16.9, post-

CIOC/PACA logos for various comet observing campaigns, designed by R. Kaufman, (Australia), G. Conzo (Italy); T. Greiner (U.S.A.) and A. Vossinakis (Greece).

conjunction by three French amateur observers (Maury, Bosch and Soulier) using a remote observatory in Chile on 12/13 April 2015, JPL issued a call for participation to the amateur community (link can be found at:

`http://rosetta.jpl.nasa.gov/rosetta-science-blog/be-part-excitement`

with mirror coverage at ESA Rosetta blog site found at:

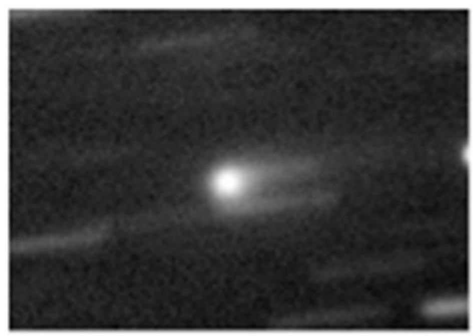
`http://blogs.esa.int/rosetta/2015/04/16/`

to announce the recovery of the comet and to encourage both professionals and amateurs to observe and characterize the comet through perihelion and several months post-perihelion, when the comets southern hemisphere (currently dark due to lack of insolation) will become very bright for a short time, even as the Rosetta spacecraft continues it high resolution spatial images of the comet exhibiting increasing jet activity over its surface, simultaneously providing two unique views : close in to the nucleus and the far-field global image of the comets coma and tail.

The amateur observers data will be collected and crowd sourced by both professionals and amateurs to characterize the comet and model it activity. The data will also be archived in ESA/Planetary Science Archive (PSA) for its legacy value too. While the spacecraft, Rosetta, in orbit around 67P/CG nucleus since August 2014, provides high resolution and multi-spectral images of the comet and its activity; maps the location and detection of various chemical species, etc., the ground-based observations (both professional and amateur) provide a complementary perspective of the evolution of the comets coma and tail. Figures below indicate the evolution of the comet and its tail, from magnitude of 16 to 13, as expected by the observations of its previous apparitions.

Latest image from 12 August 2015, a day before perihelion:

As we await eagerly the perihelion passage of the comet and images/data from Rosetta spacecraft, here is one of the latest images of comet 67P/CG, sent in by the amateur astronomer, Jean-Gabriel Bosch, imaged from the Space Observatory (Chile), showing a bright nucleus and a faint dust tail.



Comet 67P/CG imaged on 12 August 2015, one day before its perihelion passage, by amateur observer Jean-Gabriel Bosch, from the Space Observatory, Chile. The magnitude of the comet is estimated to be 12.8, and a distinct dust tail is observed.

This historic moment in cometary observations will be upon us in a few hours on 13 August 2015, as comet 67P/CG goes through its perihelion passage:

with a spacecraft in orbit around the cometary nucleus and characterize the activity with several different instruments to determine the nature of activity, abundance of chemical species through perihelion passage while ground-based professional and amateur observations will provide a timeline/reference for the Rosetta

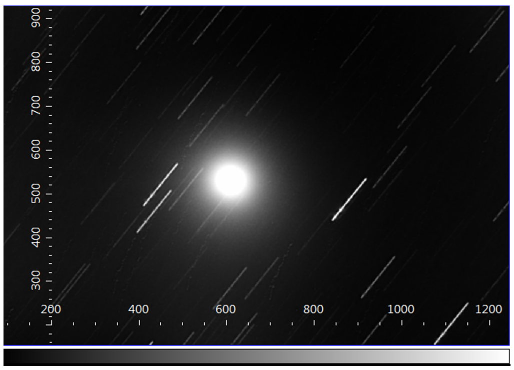
observations. The ground-based observations will provide another important resource: a bridge between legacy data sets of previous apparitions and future apparitions as the comet returns next in approximately 2021/22. A new chapter in the cometary physics is being written with ESA/Rosetta mission. Congratulations to the ESA and NASA teams for a great engineering marvel that has provided both new perspectives on cometary activity and engaged several generations of audiences globally.

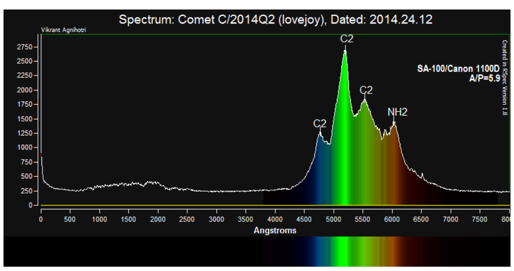
Finally, this article is a tribute to the dedicated work of the late Dr. Claudia Alexander, the US NASA Project Scientist, who passed away on 11 July 2015, on the eve of the pinnacle of both ESA/Rosetta mission and her professional career.

For more images of comet 67P/CG from PACA network:
`https://www.flickr.com/photos/pro-amastronomy/sets/72157641578093805`

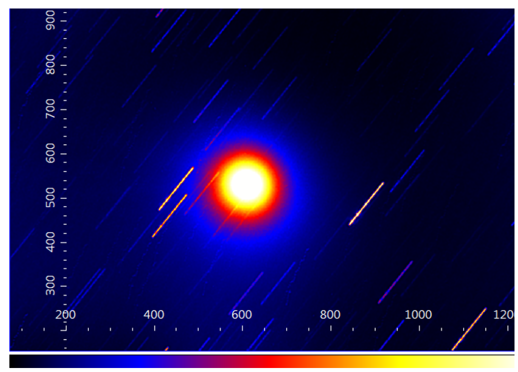
Spectroscopic study of Comet Lovejoy

Vikrant kumar Agnihotri, *Cepheid's Astronomy Club, Kota, Rajasthan*





We carried out the imaging/spectroscopy of comet C2014Q2 Lovejoy as on 24.12.2014, UT: 18:47:06. The comet imaged at sloan g'2 band (400nm-550nm) wavelength, also the spectrum captured using star analyzer grating (SA-100) within filter wheel fixed with 0.2m SCT telescope mounted on sky-watcher NEQ6 mount.



The spectral image captured over sensor KAF8300 (Atik383L+ cooled monochrome CCD) coupled with filter wheel assembly The comet image manually guided over the field of view of CCD using double cross view application of APT- Astro Photography Tool. The telescope mount was commanded using EQ-direct (ASCOM platform supported) + Starrynight (SN7). The 50 imaged are stacked in maximDL and false color imaged created in DS9. The spectral image files processed in RSpec spectroscopy software.

We examined the dia-atomic carbon (C_2) and NH_2 predominantly in comet.

Study of Cometary Atmospheres

Smitha V. Thampi, *Space Physics Laboratory*

Comets are regarded as the most pristine objects of the solar system, which preserve the information on the primitive solar nebula because they have not undergone much thermal evolution (except for the outer irradiation mantle). Comets are usually inert at large heliocentric distances, but develop a coma and tail when they come close to the Sun as the gas sublimes and evolves off the surface and dust is also dragged along. Initially, the solar wind permeates the thin comet atmosphere formed from sublimation, until the size and plasma pressure of the ionized atmosphere define its boundaries. Water (H_2O) ice is the most dominant volatile in most comets. In addition to this, cometary ices also consist of CO_2 and CO molecules and modest amounts of molecules like CH_4, NH_3, H_2CO and CH_3OH, probably contained within complex organic compounds.

The chemical composition of the comets is mostly assessed by remote sensing - spectroscopic observations. In the case of H_2O, the infrared emissions are difficult to observe from ground because of strong attenuation by the terrestrial atmosphere. Water does not have any spectroscopic transitions in UV or visible regions of solar spectrum. Hence, the emissions of the dissociative products of H_2O (OH, O and H) is studied to understand the production and spatial distribution of H_2O in comets (e.g. Furusho et al. 2006). The primary products of dissociation of H_2O molecule are H and OH. A small fraction is O and H_2. The [OI] lines (green (5577 A^o) and red-doublet (6300, 6364 ^{o}) lines) are prompt emissions of metastable oxygen atoms that have been observed in several comets, and the value of the intensity ratio of green to red-doublet (G/R ratio) has been used to identify the whether the parent source of these lines is H_2O or CO_2/CO in the coma of comets (Bhardwaj and Raghuram, 2012). The H_2O production rates in comets are also derived by observing the emissions from its dissociative products, like OH (18-cm, 3080 A^o), O (6300 A^o) and H (Lyman-alpha). Recently, Decock et al (2015) studied the G/R ratio in four comets and found that the ratio varies as a function of nucleocentric projected distance due to the collisional quenching of O(1S) and O(1D) by water molecules in the inner coma. It was also found that that the main parent species producing O(1S) and O(1D) in the inner coma is not always the same. They also discovered that the [OI] line emissions may be used to estimate the CO_2 relative abundance in comets (Decock et al., 2015). Similarly, the CO_2 production rate in comets has been derived using Cameron-band emission of CO molecules, assuming that photodissociative excitation of CO_2 is the main production mechanism of CO in the metastable state (Weaver et al., 1997). However, model calculations by Bhardwaj and Raghuram (2011) showed that photoelectron impact excitation of CO is also significant for the Cameron band emission, together with dissociative excitation of CO_2.

Apart from remote-sensing, information on the composition of comets is obtained from in situ mass spectrometry, for instance comet Halley was observed with the mass spectrometers of VEGA and Giotto. The more recent Rosetta spacecraft had three mass spectrometers, capable of studying the atmospheric composition: ROSINA (on the orbiter), Ptolemy and COSAC (both on the Philae Lander) and a suite of plasma analysers. Using the Rosetta Plasma Consortium ion composition analyzer, Nilsson et al (2015) studied the evolution of water ions on the Jupiter family comet 67P/Churyumov-Gerasimenko. The first in situ measurement of N_2 on comet 67P/Churyumov-Gerasimenko was made by the ROSINA mass spectrometer aboard the Rosetta spacecraft. Actually, though molecular nitrogen (N_2) is considered to be the most abundant form of nitrogen in the protosolar nebula, N_2 was not detected previously in comets (Rubin et al., 2015). The ROSINA, being a Double Focusing Mass Spectrometer (DFMS) has a high mass resolution of m/m about 3000 at 1 percent at atomic mass per unit charge 28 m/q, allowing the separation of N_2 from CO (Rubin et al., 2015). Very recently, Goesmann et al (2015) reported the presence of a suite of 16 organic compounds, including many nitrogen bearing species and four compounds methyl isocyanate, acetone, propionaldehyde and acetamyde on comet 67P/Churyumov-Gerasimenko, that had not been previously reported in comets. The measurements were from COSAC (COmetary Sampling And Composition) mass spectrometer, and the spectrum was obtained 25 minutes after Philaes initial touchdown. These new observations would definitely lead to new insights regarding the chemical composition of comets, the production of volatiles in comets and about the formation of cometary grains from protosolar nebula.

References

Bhardwaj and Raghuram, The Astrophysical Journal, 745:1 (18pp), doi:,:10.1088/0004-637X/745/1/1 (2012)

Bhardwaj and Raghuram, Mon. Not. R. Astron. Soc. 412, L25L29 (2011)

Decock et al., Mon. Not. R. Astron. Soc. 412, L25L29 (2011)

Furusho, R., Kawakitab, H., Fusec, T., Watanabe, J., Adv. Space Res. 9, 19831986. http://dx.doi.org/10.1016/j.asr.2006.06.003 (2006)

Goesmann et al., Science, Vol. 349, No. 6247, doi:10.1126/science.aab0689, 31 July, 2015

Nilsson et al., Science , Vol.347 no. 6220 aaa0571-1, 23 January 2015

Rubin et al., Science Express, 10.1126/science.aaa6100, 19 March 2015

Weaver H. A., Feldman P. D., McPhate J. B., ApJ, 422, 374, (1994)

Concept for a comet chaser/flyby mission

Dr. Shashikiran Ganesh, *Physical Research Laboratory, India*

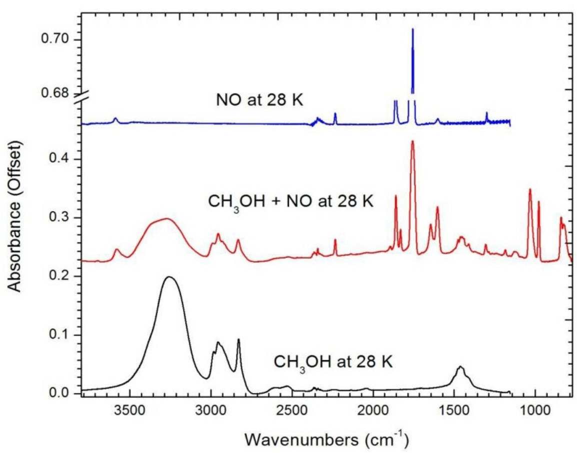
Mars Orbiter Mission (MOM) showcased ISRO's potential in deep space navigation with a great success in the maiden venture. The technology has been demonstrated and now is the time for Indian scientists to take advantage of the capabilities. One of the key areas that need to be addressed with a dedicated space mission is that of long period comets. Long period comets are supposed to be relatively less affected by weathering due to lesser number of close perihelion passes. Hence their study would allow us better understanding of the pristine building blocks at the early stages of Solar System evolution.

So far, all the missions to comets, starting with International Cometary Explorer (ICE) to the current Rosetta/Philae, have targeted short period comets where the orbits are relatively well known, understood and predictable with reasonable accuracy. The recent encounter of Comet C/2013 A1 (Siding Spring) with Mars is a unique case where spacecraft meant for Mars observations (including MOM) were able to contribute to study of the comet.

Thus a comprehensive mission with a suite of instruments must be designed, built and kept on standby for launch to a long period comet that would make a suitable pass through the inner Solar system. Long period comets such as the massive Comet C/1995 O1 (Hale-Bopp) are discovered when they are sufficiently far enough away. Hence they provide for a sufficient lead time for computing and setting a deep space course for a suitable flyby of the comet. Again taking the case of Hale-Bopp, the comet was discovered on 23rd July 1995 at a distance of over 7AU and approached perihelion (distance of 0.9AU) on 1st April 1997. Generally long period comets are in orbits with very different inclination angles with the ecliptic and getting spacecraft to follow those orbits would be quite demanding in terms of power for trajectory mapping and corrections. It would be a very rare orbit that would allow us to accompany the comet as being done by the Rosetta spacecraft. Hence a precisely timed flyby would be most appropriate to sample the comet. It is here that ISRO's recently demonstrated potential for cheap, low gestation missions can make a unique mark in planetary exploration on an international scale.

Spectroscopy and Chemical Synthesis of Interstellar Ice Analogues (Thesis Abstract)

Binukumar G Nair, *The Open University, UK.*



Absorption spectra of pure NO ice, CH_3OH+NO [1:1] ice mixture and, pure CH_3OH ice at deposited at 28 K.

Molecular synthesis and chemical evolution in the interstellar medium has been studied under laboratory conditions. The method of preparation and energetic processing of interstellar ice analogues on surfaces, spectroscopic principles for monitoring chemistry and morphology of these ice analogues and analysis methodologies are discussed in detail.

The modification of a portable, ultra-high vacuum (UHV) system for electron irradiation, vacuum ultraviolet (VUV) spectroscopy and temperature programmed desorption (TPD) of interstellar ice analogues are described in this thesis. Experimental procedures to grow interstellar ice analogues of pure molecules and mixtures are described. The results from the various experiments discussed in this thesis are classified into four main parts: VUV spectroscopy, electron irradiation of interstellar (IS) ice analogues, simultaneous irradiation and generation of IS ice analogues and temperature programmed desorption of interstellar ice analogues.

Temperature dependent vacuum ultraviolet (VUV) photo-absorption spectra of pure molecular ices such as $HCONH_2$, HCOOH, $HCOOCH_3$, CH_2CHCH_2OH CH_3COOCH_3, CH_3CH_2COOH, C_6H_6 and O_3 have been measured on the UV1 beamline of the ASTRID Synchrotron at the University of Aarhus in Denmark and UV A1 beamline at NSRRC, Taiwan. These spectra and photo-absorption cross-sections in the condensed phase are also presented. In particular, temperature dependent VUV photo-absorption characteristics of condensed ice films of O3 are measured for the first time. Electron induced molecular synthesis in pure organic ice films of $HCONH_2$, $HCOOCH_3$, CH_3COOH, NO and binary ice mixtures of CH_3OH+NO (1:1) are also reported. Newly identified pathways of molecular synthesis and results of electron destruction cross-sections are discussed. Molecular synthesis during simultaneous electron irradiation and physisorption of a

binary mixture of CH_3OH+NH_3 (1:1) is studied for the first time. Simultaneous irradiation-deposition has shown very interesting behaviour in terms of efficiency of formation of radical species such as OCN^-, NH_4^+ etc and biologically important complex organic species such as $HCONH_2$, $HCOOCH_3$, CH_3COOH, CH_3OCH_3, CH_2CHCHO etc. Simultaneous irradiation-deposition closely simulate the effect of cosmic ray irradiation in a dense molecular cloud and reveal new pathways of formation with higher efficiencies even at lower column densities of reactants. Finally preliminary results of a temperature programmed desorption study of pure NO ice films are also presented along with the future challenges and strategies.

For full thesis please write to:
binukumarg@gmail.com

Events

Topical Conference on

Charged Particle Collisions and Electronic processes in Atoms, Molecules and Materials

q-PaCE 2016

9-11 January 2016

ISM, DHANBAD, INDIA

Conference Themes

- Electron-atom / molecule collision.
- Positron-atom / molecule collision.
- Ion-atom / molecule collision.
- Electron spectroscopy.
- Electronic processes in atoms, molecules and condensed matter.
- Electron-phonon and electron-photon interactions.
- Applications of collision and spectroscopic data in atmospheric sciences, astrochemistry, solar and interstellar media, natural and industrial plasma, laser physics, accelerator physics, radiation chemistry and biological sciences.

For more information: http://qpace2016.in/ismconference/

NASA Spaceward Bound India 2016

Motivation

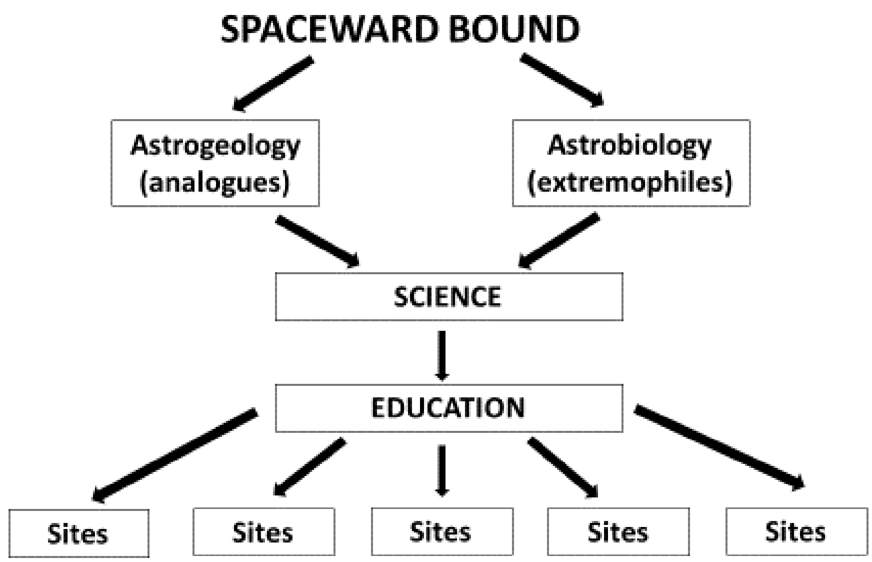
NASA Spaceward Bound is an Astrobio-geological research oriented educational program started at NASA Ames Research Center. The goal is bring a team of researchers, educators and students to Off -Earth analogue sites to investigate the geological features and study microbial diversity in such remote and extreme environments. Over the years, Spaceward Bound teams have conducted expeditions in Mohave desert, Idaho in the US, Namibia, UAE, Australia, New Zealand and Polar regions. The project serves as an excellent opportunity for local educators and students to work alongside planetary science researchers and get inspired to take up similar careers. Previous work has resulted in a number of peer reviewed journal publications. The planners of Spaceward Bound have decided to visit Ladakh, India in July-August 2016 time frame.

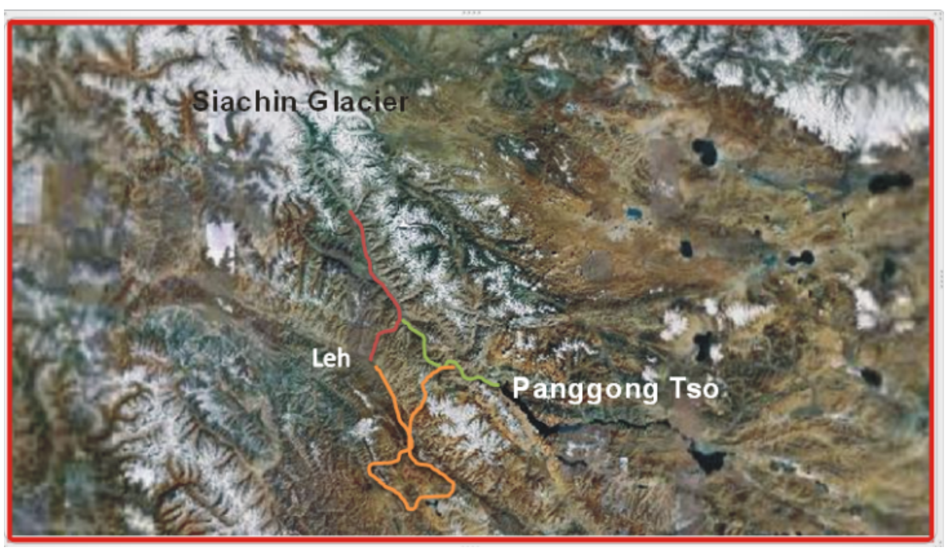
Spaceward Bound India Theme

Cold, high altitude desert, permafrost, soda lake, hot spring ecosystems (figure above on the right shows the 3 transects in red, green and orange)

Science Definition Teams

SG 1a: Understanding constitution and abundance of microbial communities and correlation with harsh physico-chemical conditions
SG 1b: Clay extraction from collected mud and sediment samples to evaluate for catalytic capabilities. Lipid composition analysis from bio-relevant samples.


SPACEWARD BOUND
Astrogeology
(analogues)
Astrobiology
(extremophiles)
SCIENCE
EDUCATION
Sites
Sites
Sites
Sites
Sites


Siachin Glacier
Leh
Panggong Tso

SG 1c: Lipid biomarker detection and quantification using lab-on-chip tools for life detection on future planetary missions.
SG 2: Glacial, fluvial and lacustrine landform surface process study, rock weathering rate study and past landform and climatological reconstruction.
SG 3: To investigate the main carbon source and mode of their assimilation using compound specific stable isotope probing. To investigate the biogenic methagenesis at subzero temperatures using compound specific stable isotope probing.

Project Plan

As of now, based on the transect plan, the science teams have established their experiment plans for the expedition. The educator activity plan is being prepared to help train the students on the expedition. We plan on taking a team of 30 members (including researchers, educators and students) for duration of 12 days. The project is currently being planned for July- August 2016 time frame. The MoU shall soon be released indicating the participating institutions and their responsibilities.

Planning Committee

Project Coordinator: Mr. Siddharth Pandey (1, 2, 4) Science Coordinator: Dr. Jonathan Clarke (2) Logistics Coordinator: Dr. Mukund Sharma (3)

Science Definition Committee:

Dr. Binita Phartiyal (3), Dr. Jen Blank (4,5), Dr. Jon Clarke (2), Dr. Martin VanKranendonk (10), Dr. Mukund Sharma (3), Dr. Parag Vaishampayan (4,8), Dr. Preeti Nema (4), Dr. Rakesh Mogu (I,9), Dr. Rosalba Bonaccorsi (5,6), Dr. Sanjoy Som (4,5), Mr. Siddharth Pandey (1,2,4) Dr. Steve Hobbs (2), Dr. Sudha Rajamani (7)

(1) University of New South Wales, (2) Mars Society Australia, (3) Birbal Sahni Institute of Palaeobotany, (4) Blue Marble Space, (5) NASA Ames Research Center, (6) SETI, (7) IISER, (8) NASA JPL, (9) Calpoly Pomona (10) Australian Center of Astrobiology

Contact Information

Name: Siddharth Pandey
Email: spacewardbound@astrobiologyindia.in

Opportunities

- **Indian Centre for Space Physics invites application from the candidates for the post of Project Scientists and Post Doctoral Fellows in Astrophysics, Earth and Space Science.**

  Contact Dr. Ankan Das: ankan@csp.res.in

- **PDF Position - Recovering geochemical evolution of Mars from the study of Martian meteorities.**

  Contact Dr. Amit Basu: amitbs@prl.res.in.

- **PDF Position - Simulating astrochemical ices in the laboratory. Opportunity to build an experimental setup to study chemical synthesis of low temperature molecular ices under shock conditions.**

  Contact Dr. Bhalamurugan Sivaraman: bhala@prl.res.in

- **PDF Position - Linking Comets with cold ISM clouds.**

  Contact Dr. Shashikiran Ganesh: shashi@prl.res.in

For more information:
http://www.prl.res.in/~ acsi/

Recent Books on Comets

1. **Author: Alan Hale**

   Title: The Comet Man

   Link:
   http://www.earthriseinstitute.org/thecometman.html

2. **Author: Uwe Meierhenrich**

   Title: Comets and their Origin

   Link:
   http://as.wiley.com/WileyCDA/WileyTitle/productCd-3527412816,subjectCd-ES12.html

ASTROPROJECT

Captured on 14/12/2013.

Location: Mount Abu Infrared observatory, Mt Abu, Rajasthan, India.

Comet C/2013 R1 (Lovejoy) photographed by Rakesh Rao rising over the light polluted Abu valley. Also seen is a sporadic meteor burning up in the Earth atmosphere.

The sharp line near the horizon marks the edge of the boundary layer of the atmosphere frequently seen in winter at Mt Abu.

Invitation for Submitting Letters

We are pleased to invite your articles (in the form of a 2-3 paragraphs and an image if possible) for the next issue.

Kindly email your articles to acsi@prl.res.in

To stay tuned about the updates in Astrochemistry, check our website:

http://www.prl.res.in/∼ acsi/

Facebook:

https://www.facebook.com/astrochemistryindia?fref=ts

Twitter:

https://twitter.com/AstrochemPrl

Office Bearers of the Society:

Bhalamurugan Sivaraman and Shashikiran Ganesh

Physical Research Laboratory, India

Email id: *bhala@prl.res.in, shashi@prl.res.in*

NATIONAL EDITORIAL BOARD