

## **BIOASTRONOMY 09**

### **Introduction**

Bioastronomy is concerned with the study of the origin, evolution, distribution and destiny of life in the universe. ('Exobiology' is a synonym often in use, but more recently 'astrobiology' is preferred, cf., <http://www.ictp.it/~chelaf/ss94>) This field was established at the ICTP in 1991 by the combined efforts of Abdus Salam, Cyril Ponnampereuma and the present author. Research, seminars and conferences in bioastronomy have attracted a large number of scientists to the Centre.

### **Research**

The distribution of life in the universe is the aspect of bioastronomy that can encourage successful interdisciplinary dialogue with other scientists from the Applied Physics, as well as other scientific sections of the Abdus Salam ICTP. (The other three aspects of bioastronomy are enumerated above.) The cosmic distribution of life still lacks solid theoretical, or observational bases.

Nevertheless, the question of distribution can be probed in terms of a wide range of planetary exploration missions especially dedicated to study whether, or not, we are alone in the universe, as for instance the Europa-Jupiter System Mission now in its planning stages, (cf., Fig 1):

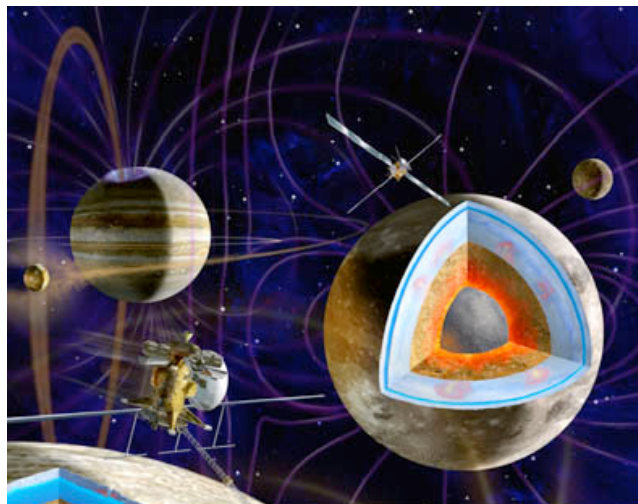


Fig. 1: The proposed baseline of the Europa Jupiter System Mission, EJSM (NASA, ESA, ROSCOSMOS, JAXA) consists of two primary flight elements operating in the Jovian system: the NASA-led Jupiter Europa Orbiter (JEO), and the ESA-led Jupiter Ganymede Orbiter (JGO). JEO and JGO will execute a choreographed exploration of the Jupiter System before settling into orbit around Europa and Ganymede, respectively.

## Experimental

The main space agencies have undertaken a sustained effort to search for biosignatures. The discoveries of the successful Galileo mission took place during its fourteen-year activity (1989-2003). Its Near-Infrared Mapping Spectrometer led to the discovery of a series of unexpected lines on the icy surface of the Jovian satellite Europa, due to patches of chemical element impurities. Can some of these new lines be due to the presence of life in the submerged ocean? Could they be interpreted as biosignatures? The relevance of theoretical work at ICTP is to suggest feasible experiments that are possible, not only with present technology, but also within the agency budgets. Originally we had suggested the insertion of a submersible underneath the ice crust (cf., Fig.2):



Fig. 2: The earlier hydrobot-cryobot proposal for directly probing Europa's ocean, Horvath *et al*, (1997), [http://www.ictp.it/~chelaf/searching\\_for\\_ice.html](http://www.ictp.it/~chelaf/searching_for_ice.html)

Even though we were attracted to this technology in our earlier paper, we no longer consider it to be realistic, due to the limited budgets to which all the space agencies are constrained. Fortunately, the corresponding study of a surficial biosignature offers a viable alternative that has already been successfully accepted for publication in specialized literature during the year 2009 (cf., Publications, Chela-Flores, 2010a), and remains a possible option for future missions that are currently in their planning stages, and to which since the 1990s the Abdus Salam ICTP continues participating in the question of identifying the relevant instrumentation (cf., next section).

## Theoretical, experimental and technological

In the search for biosignatures on Europa on the sulphur patches discovered by the Galileo mission the most appropriate technology—the penetrator—is currently being further developed by the UK Penetrator Consortium for preliminary trials on our own Moon. These instruments consist of small projectiles that can be delivered at high velocity to reach just beneath the surface of planets, or their satellites for probing samples of surficial chemical elements. This type of instrumentation (the penetrators) has a long history of feasible technological development by several space agencies. The research at the ICTP has focused on the type of instruments that the penetrators should be provided with from the point of

view of the search for life signatures (cf., Publications, Gowen *et al.*, 2010 submitted).

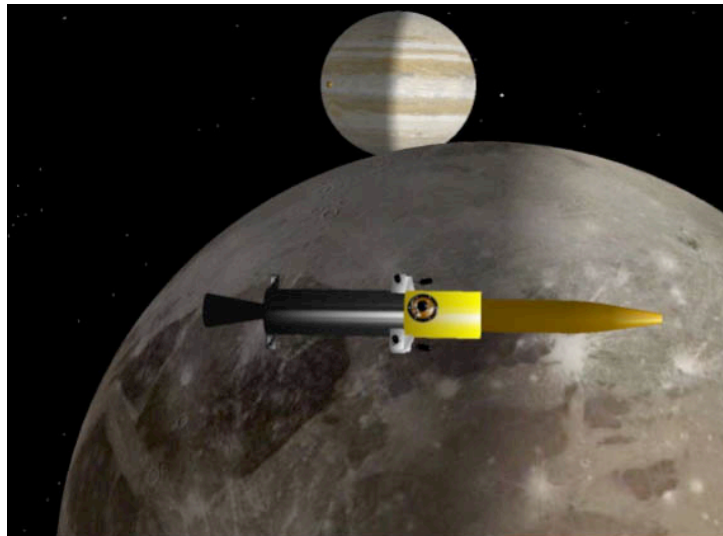


Fig. 3: The penetrator as it should appear approaching Europa (with Jupiter in the background). This technology is currently being further developed by the UK Penetrator Consortium for preliminary trials on our own Moon but for an eventual use on Europa. (cf., Participation in International Meetings, Gowen *et al.*, 2009a).

## Participation in International Programmes

**Declaration of Interest in science instrumentation in response to the Announcement of Opportunity for Europa Jupiter System Mission (EJSM/Laplace) Cosmic Vision Candidate: Surface Element Penetrators, May 2009** Robert Gowen, Alan Smith, Richard Ambrosi, Olga Prieto Ballesteros, Simeon Barber, Dave Barnes, Chris Braithwaite, John Bridges, Patrick Brown, Phillip Church, Glyn Collinson, Andrew Coates, Gareth Collins, Ian Crawford, Veronica Dehant, Michele Dougherty, **Julian Chela-Flores**, Dominic Fortes, George Fraser, Yang Gao, Manuel Grande, Andrew Griffiths, Peter Grindrod, Leonid Gurvits, Axel Hagermann, Toby Hopf, Hauke Hussmann, Ralf Jaumann, Adrian Jones, Geraint Jones, Katherine Joy, Ozgur Karatekin, Günter Kargl, Antonella Macagnano, Anisha Mukherjee, Peter Muller, Ernesto Palomba, Tom Pike, Bill Proud, Derek Pullen, Francois Raulin, Lutz Richter, Simon Sheridan, Mark Sims, Frank Sohl, Joshua Snape, Jon Sykes, Vincent Tong, Tim Stevenson, Lionel Wilson, Ian Wright, John Zarnecki:[http://www.mssl.ucl.ac.uk/planetary//missions/Cosmic\\_Vision\\_EJSM\\_Penetrators\\_DOI.pdf](http://www.mssl.ucl.ac.uk/planetary//missions/Cosmic_Vision_EJSM_Penetrators_DOI.pdf)

## Participation in International Meetings

**Chela-Flores, J.**, Bhattacharjee, A. B., Dudeja, S., Kumar, N. and Seckbach, J. 2009. Can the biogenicity of Europa's surficial sulfur be tested simultaneously with penetrators and ion traps? Geophysical Research Abstracts, Vol. 11, EGU2009-0, 2009, EGU General Assembly 2009. The Austria Centre, Vienna, 22 April.  
<http://www.ictp.it/~chelaf/EGU2009JCTetal.pdf>

- Seckbach, J. and **Chela-Flores, J.** 2009. Astrobiology: From extremophiles in the Solar System to extraterrestrial civilizations, Astronomy and Civilization, Budapest – August.  
<http://www.ictp.it/~chelaf/Budapest.pdf>
- Gowen, Robert, Alan Smith, Richard Ambrosi, Olga Prieto Ballesteros, Simeon Barber, Dave Barnes, Chris Braithwaite, John Bridges, Patrick Brown, Phillip Church, Glyn Collinson, Andrew Coates, Gareth Collins, Ian Crawford, Veronique Dehant, Michele Dougherty, **Julian Chela-Flores**, Dominic Fortes, George Fraser, Yang Gao, Manuel Grande, Andrew Griffiths, Peter Grindrod, Leonid Gurvits, Axel Hagermann, Tim van Hoolst, Hauke Hussmann, Ralf Jaumann, Adrian Jones, Geraint Jones, Katherine Joy, Ozgur Karatekin, Günter Kargl, Antonella Macagnano, Anisha Mukherjee, Peter Muller, Ernesto Palomba, Tom Pike, Bill Proud, Derek Pullen, Francois Raulin, Lutz Richter, Keith Ryden, Simon Sheridan, Mark Sims, Frank Sohl, Joshua Snape, Paul Stevens, Jon Sykes, Vincent Tong, Tim Stevenson, Werner Karl, Lionel Wilson, Ian Wright, John Zarnecki 2009a. Looking for Astrobiological Signatures with Penetrators on Europa, in Physical and Engineering Sciences Exploratory Workshops, W08-115, co-funded by Life, Earth and Environmental Sciences: Biosignatures On Exoplanets; The Identity Of Life , 22-26 June, Mulhouse, France .  
<http://www.ictp.it/~chelaf/ESFsummary.pdf>
- Gowen, Robert, Alan Smith, Richard Ambrosi, Olga Prieto Ballesteros, Simeon Barber, Dave Barnes, Andrew Bowyer, Chris Braithwaite, John Bridges, Patrick Brown, Phillip Church, Glyn Collinson, Andrew Coates, Gareth Collins, Ian Crawford, Veronique Dehant, Michele Dougherty, Jeremy Fielding, **Julian Chela-Flores**, Dominic Fortes, George Fraser, Yang Gao, Manuel Grande, Andrew Griffiths, Peter Grindrod, Leonid Gurvits, Axel Hagermann, Tim vanHoolst, Hauke Hussmann, Ralf Jaumann, Adrian Jones, Geraint Jones, Katherine Joy, Ozgur Karatekin, Günter Kargl, Antonella Macagnano, Anisha Mukherjee, Peter Muller, Ernesto Palomba, Andy Phipps, Tom Pike, Bill Proud, Derek Pullen, Francois Raulin, Lutz Richter, Keith Ryden, Simon Sheridan, Mark Sims, Frank Sohl, Joshua Snape, Paul Stevens, Jon Sykes, Vincent Tong, Tim Stevenson, Nigel Wells, Werner Karl, Lionel Wilson, Ian Wright, John Zarnecki 2009b. An update on micro-penetrators for in-situ sub-surface investigations of Europa, Europa Jupiter System Mission (EJSM) Instrument Workshop, JPL and the Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland, July 15-17.  
<http://www.ictp.it/~chelaf/NASAabstract09.pdf>
- Gowen, Robert, Alan Smith, Richard Ambrosi, Olga Prieto Ballesteros, Simeon Barber, Dave Barnes, Andrew Bowyer, Chris Braithwaite, John Bridges, Patrick Brown, Phillip Church, Glyn Collinson, Andrew Coates, Gareth Collins, Ian Crawford, Veronique Dehant, Michele Dougherty, Jeremey Fielding, **Julian Chela-Flores**, Dominic Fortes, George Fraser, Yang Gao, Manuel Grande, Andrew Griffiths, Peter Grindrod, Leonid Gurvits, Axel Hagermann, Tim van Hoolst, Toby Hopf, Hauke Hussmann, Ralf Jaumann, Adrian Jones, Geraint Jones, Katherine Joy, Ozgur Karatekin, Günter Kargl, Antonella Macagnano, Anisha Mukherjee, Peter Muller<sup>1</sup>, Ernesto Palomba, Andy Phipps, Tom Pike, Bill Proud, Derek Pullen, Francois Raulin, Lutz Richter, Keith Ryden, Simon Sheridan, Mark Sims, Frank Sohl, Joshua Snape, Paul Stevens, Jon Sykes, Vincent Tong, Tim Stevenson, Nigel Wells, Lionel Wilson, Ian Wright, John Zarnecki 2009c. *In-situ Science on the surfaces of Ganymede and Europa with Penetrators*, European Planetary Science Congress Abstracts, Vol. **4**, EPSC2009, 2009 European Planetary Science Congress, Potsdam, Kongresshotel am Templiner See: 13 – 18 September.  
[http://www.ictp.it/~chelaf/Gowen\\_abstract.pdf](http://www.ictp.it/~chelaf/Gowen_abstract.pdf)

# Training Activities: Supervision of Associate Members of ICTP

## Senior Associates

Name: **Tewari, Vinod C.**  
Research Field: Bioastronomy  
Institute: Wadia Institute of Himalayan Geology, Dehradun, India

## Service activities within ICTP

### Seminars of the Applied Physics Scientific Section

RELIABILITY OF GATE OXIDES: APPLICATIONS TO SPACE  
EXPLORATION  
Felix R. M. Palumbo  
Physics Department, CONICET - CNEA, Buenos Aires, Argentina  
*26 February 2009*

DARWIN: TRACES ON ICE  
Nevio Pugliese and co-workers of the Antarctic Museum  
Dipartimento di Scienze Geologiche, Ambientali e Marine  
Università degli Studi di Trieste  
*26 March 2009*

PALEORADIOLOGY: IMAGING MUMMIES AND FOSSILS  
Rethy Chhem  
Director of the Division of Human Health  
International Atomic Energy Agency, Vienna  
*11 May 2009*

PROPOSAL OF AN OPTICALLY STIMULATED LUMINESCENCE READER  
AT THE ABDUS SALAM ICTP  
F. O. Ogundare  
Department of Physics, University of Ibadan, Ibadan, Nigeria  
*28 September 2009*

IONOSPHERIC PHYSICS AND SPACE WEATHER RESEARCH IN CUBA  
Alexander Calzadilla-Méndez  
Instituto de Geofísica y Astronomía, Departamento de Geofísica Espacial,  
Ciudad de la Habana, Cuba  
*7 October 2009*

MODELLING HUMAN BONE MINERAL DENSITY  
Rita Cassia-Moura  
Biophysics Division, Physiological Sciences Department  
Biological Sciences Institute, Pernambuco University, Recife, BRAZIL  
*29 October 2009*

HARDWARE IMPLEMENTATION OF PARTICLE FILTERS  
Imbaby I. Mahmoud  
Atomic Energy Authority, NRC, Engineering Department, Cairo, Egypt  
*4 November 2009*

STABLE ISOTOPE TECHNIQUE IN THE EVALUATION OF SOIL PHYSICAL  
QUALITY  
Mutiu A. Busari  
Department of Soil Science and Land Management, University of Agriculture,  
Abeokuta, Nigeria  
*11 November 2009*

**Other seminars (including Physics of the Living State: Medical Physics)**

NANOTECHNOLOGY FOR APPLICATIONS IN THERAPEUTICS  
Sangeeta Kale  
Nanoscience Group, Post-graduate and Research Centre Department of  
Electronic-Science, Fergusson College, Pune, India  
*3 June 2009*

ON THE SAFETY OF PERSONS ACCOMPANYING NUCLEAR MEDICINE  
PATIENTS  
Marlenin Díaz Barreto  
National Control Center for Medical Devices, Havana, Cuba.  
*26 August 2009*

ANALYZING AND IMPROVING DIGITAL MEDICAL IMAGE QUALITY  
Cuban experiences in Magnetic Resonance and Nuclear Medicine  
Marlen Perez Diaz  
Central University "Las Villas", Electrical Engineering Faculty, Santa Clara,  
Cuba  
*16 September 2009*

PATIENT RADIATION DOSES DURING SELECTED CT EXAMINATIONS AT  
A LARGE HOSPITAL IN SW NIGERIA  
Rachel Ibhade Obed  
Physics Department, University of Ibadan, Ibadan, Nigeria  
*23 September 2009*

**Service Activity at the ICTP:**

**Coordination, Seminars on Physics of the Living State (Bioastronomy)**

METABOLIC ADAPTATION: FROM A PREBIOTIC LIPID WORLD TO  
OPTIMAL ORGANIZATION  
Daniel Segre  
Bioinformatics Program, Boston University, United States of America  
*16 June 2009*

## Science Communication (Bioastronomy)

### 1. La notte dei ricercatori:

an informal dialogue with the citizens of Trieste,  
25 September 2009.  
<http://www.ictp.it/~chelaf/ss237.html>

### 2. Darwin-Anniversary Activities

(<http://www.ictp.it/~chelaf/ss223>)

For the two anniversaries in the year 2009 (the 200th anniversary of the birth of Charles Darwin in 1809 and the 150th anniversary of the publication of "The Origin of Species" in 1859), The Abdus Salam International Centre for Theoretical Physics (ICTP) in collaboration with other institutes in Trieste and the UNESCO Office in Venice, organized an exhibition to commemorate these two events. We participated in the following activities:

#### (a) Coordinator and speaker during the the visits to the ICTP Darwin Exhibition (November-December 2009)

Liceo Scientifico Galileo Galilei (Trieste), 25 November 2009.

Liceo Veronese di Chioggia, 1 dicembre 2009.

Liceo Linguistico di Portogruaro, 2 dicembre 2009.

Scuola Elementare U. Saba and Scuola Elementare Tarabocchia (Trieste), 3 dicembre 2009.

Scuola Media Codermatz (Trieste), 4 dicembre 2009.

Scuola Elementare Giotti (Trieste), 9 dicembre 2009.

Scuola elementare Biagio Marin (Trieste), 14 dicembre 2009.

#### (b) Conferences related to the UNESCO Darwin celebrations (Venice and Trieste)

Chela-Flores, J. (2009a). L'origine della vita nell'universo. In: Darwin e la Scienza Moderna, UNESCO Office, Palazzo Zorzi, Venice 29 April.  
<http://www.ictp.it/~chelaf/JCFVenezia1.pdf>

Chela-Flores, J. (2009b). L'origine della vita nell'universo. In: Darwin, evoluzione e scienza. (Miniconferenza, 24 Novembre 2009.)  
<http://www.ictp.it/~chelaf/ss246>

## Service activities outside ICTP

### ORGANIZATION OF SCIENTIFIC EVENTS

II IBEROAMERICAN SCHOOL OF ASTROBIOLOGY, Organizer Prof. Guillermo Lemarchand. Montevideo, Uruguay, September 13-17, 2009. *Member of the Scientific Organizing Committee.*

II INTERNATIONAL WORKSHOP ON CHEMICAL EVOLUTION AND ORIGIN OF LIFE.

Department of Chemistry, Indian Institute of Technology, Roorkee, India. Organizer: Professor Kamaluddin, March 5-7, 2010. *Member of the International Advisory Committee.*

III WORKSHOP DELLA SOCIETÀ ITALIANA DI ASTROBIOLOGIA  
Castello di Duino, Trieste, May 26-28, 2010. *Member of the Scientific  
Organizing Committee.*

MEMBER OF EDITORIAL BOARDS, REVIEWER

Member of the editorial board of the book series on "Cellular Origin and Life in  
Extreme Habitats and Astrobiology" (Springer).

Reviewer for  
Advances in Space Research and  
Planetary and Space Science.

EXTERNAL EXAMINER

"System Study and Design of a Multi-probe Mission for Planetary in-situ  
Analysis", Mr. Peter Weiss. Ph.D. examination, The Hong Kong Polytechnic  
University, 22 February 2010.

**Staff and Long-Term Visitors** (3 months or more)

**Staff Associate**

Julian Chela-Flores (República Bolivariana de Venezuela)  
<http://www.ictp.it/~chelaf/index.html>

**Publications**

**Published**

1. Messerotti, M. and **Chela-Flores, J.** 2009. Solar Activity and Life. A Review. *Acta Geophysica* **57** 64-74.  
<http://www.ictp.it/~chelaf/MesserottiJCF.pdf>
2. Chela-Flores, J. 2010a. Instrumentation for the search of habitable ecosystems  
in the future exploration of Europa and Ganymede. *International Journal of  
Astrobiology*, **9** (2) 1-8.  
<http://www.ictp.it/~chelaf/jcfSeamless.pdf>
3. **Chela-Flores, J.** Jerse, G., Messerotti, M. and Tuniz, C. 2009. Astronomical  
and astrobiological imprints on the fossil records. A review. J. Seckbach (ed.)  
*From Fossils to Astrobiology*. Springer, Dordrecht, The Netherlands, 389-408.  
<http://www.ictp.it/~chelaf/FOASfinal.pdf>
4. Tewari, V. C. and **Chela Flores, J.** 2009. Possible Role of Sulfur on the Early  
Diversification of Life on Earth: Astrobiological Implications. K.L. Srivastava  
(ed.) *Economic Mineralisation Scientific Publishers*, Jodhpur, India, 53-56.  
<http://www.ictp.it/~chelaf/TewariJCF.pdf>
5. Blanc, M. et al, and **LAPLACE Team Members** 2009. LAPLACE: a mission to  
Europa and the Jupiter System for ESA's Cosmic Vision Programme,  
*Experimental Astronomy*, **23** 849-892.  
<http://www.ictp.it/~chelaf/LAPLACE.pdf>  
LAPLACE Team Members were in: <http://www.ictp.it/~chelaf/ss164.html>



6. Chela-Flores, J. 2009b. *A Second Genesis: Stepping-stones towards the intelligibility of nature*, World Scientific Publishers, Singapore, 248 pp.  
<http://www.ictp.it/~chelaf/ss220.html>
7. Chela-Flores 2009c. Una fábula de nuestro tiempo. *Arte y Educación*, Caracas, 20-25.  
<http://www.ictp.it/~chelaf/UnaFabula05June09.pdf>
8. Chela-Flores, J. 2010d. From the Moon to the Moons: Encedalus and Europa. The Search for Life and Reliable Biomarkers. *Journal of Cosmology* **5** 971-981.  
<http://journalofcosmology.com/SearchForLife110.html>

### ***In press***

1. **Chela-Flores, J.**, Montenegro, M.E., Pugliese, N. Tewari, V.C. and Tuniz, C. 2010. Evolution of plant-animal interactions. J. Seckbach and Z. Dubinsky and (eds.). To appear in *All flesh is grass: Plant-Animal Interactions, a love-hate affair*. Springer, Dordrecht, The Netherlands.  
<http://www.ictp.it/~chelaf/PLAN.pdf>
2. Dudeja, S., Bhattacharjee, A. B. and **Chela-Flores, J.** 2010. Microbial mats in Antarctica as models for the search of life on the Jovian moon Europa. J. Seckbach and A. Oren (eds.) To appear in *Microbial Mats*, Springer.  
<http://www.ictp.it/~chelaf/Dudeja.pdf>
3. Seckbach, J., Ericksson, P. G., Walsh, M. M., Oren, A. and **Chela-Flores, J.** 2010. Microbial Mats: Summary and Conclusions. J. Seckbach and A. Oren (eds.) To appear in *Microbial Mats*, Springer.  
<http://www.ictp.it/~chelaf/MIMAFinalChapt.pdf>
4. **Chela Flores, J.** and Tewari, V. C. 2010. The sulfur cycle on the early Earth: Implications for the search of life on Europa and elsewhere. J. Seckbach and V. Tewari (eds.) To appear in *Stromatolites*, Springer.  
<http://www.ictp.it/~chelaf/finalTewJCF1.pdf>
5. Seckbach, J. and **Chela-Flores, J.** 2010. Astrobiology: From extremophiles in the Solar System to extraterrestrial civilizations. A. Hanslmeier, S. Kempe and J. Seckbach (eds.). To appear in *Life on Earth and Planets*, Springer,  
<http://www.ictp.it/~chelaf/Budapest.pdf>

### ***Submitted***

1. Gowen, R., Smith, A., Ambrosi, R., Prieto Ballesteros, O., Barber, S., Brown, P., Church, P., Collinson, G., Coates, A., Collins, G., Crawford, I., Dehant, V., **Chela-Flores, J.**, Fortes, D., Fraser, G., Gao, Y., Griffiths, A., Grindrod, P., Gurvits, L., Hagermann, A., Hopf, T., Hussmann, H., Jaumann, R., Jones, A., Jones, G., Joy, K., Karatekin, O., Kargl, G., Macagnano, A., Mukherjee, A., Muller, P., Palomba, E., Pike, T., Pullen, D., Raulin, F., Richter, L., Sheridan, S., Sims, M., Sohl, F., Snape, J., Sykes, J., Stevenson, T. and Wells, N. 2010. Micro-penetrators for in-situ sub-surface investigations of Europa. *Advances in Space Research*.