Host Organization: University of Hertfordshire, Hatfield, UK
Host Researcher: Prof. Joseph Ulanowski
Scientific Area: Atmospheric Electricity
Grant: COST Action CA15211 – Electronet
2nd STSM Call Period: 01/04/18 – 30/04/18
Visit Period: 22/04/18 – 28/04/18

Short Term Scientific Mission (STSM) Grant Report

The STSM applicant submits this report for approval to the STSM coordinator

1. Report Summary:

As stated in the extended proposal summary, the planned Short Term Scientific Mission took place between the **22/04/2018** to **28/04/2018**, solely within the premises of the University of Hertfordshire, in the School of Physics, Astronomy and Mathematics, more specifically in the Centre for Atmospheric and Climate Physics Research (CACP - https://www.herts.ac.uk/research/centres-and-groups/cacp). The scientific visit was successfully completed under the supervision of Prof. Joseph Ulanowski, with all the proposed discussions and activities being integrated. Concerning the given educative talks and laboratory experiments, there was a tightly followed schedule within the week, which provided the opportunity to cover the entirety of the questioned subjects of desert dust electrification processes, but also for clarifying various topics concerning the scattering properties of dust particles.

CACP's research is carried out in **seven** dedicated research laboratories and darkrooms.

Facilities include:

- Two Laser Scattering Research Laboratories equipped at state-of-the-art equipment and instrumentation for light scattering research and particle optical characterization
- Two Instrumentation Research Laboratories equipped with precision machining and fabrication facilities (used primarily by CACP Particle Instruments Research group)
- Electrodynamic trap for light scattering measurements on single particles in single and randomized orientations
- A JOEL scanning electron microscope suite with Energy-dispersive X-ray Spectroscopy
- A 2136-core computer cluster supporting both astronomy research and theoretical light scattering modelling research
- Optical, electronic, and mechanical design and simulation software tools including Zemax™, Cadstar™, Inventor™ and other computer tools
- Instruments for the generation, control and characterization of aerosols and individual airborne particles
- An 'Objet 30' 3D-printer facility for rapid prototyping of precision plastic parts used in both fundamental experimental research and instrument development
- A dedicated Atmospheric Analysis Laboratory equipped with Energy Dispersive X-Ray Fluorescence for multi-elemental analysis, Gas Chromatography with Mass Spectrometer, Ion

Chromatography, Inductively Coupled Plasma Spectrometry and number of traceable air quality sampling instruments

- Instrumentation for real-time measurement of ultrafine to coarse aerosol number and mass size distributions

2. Refined Visit Schedule

For comparison purposes, the proposed detailed work plan can be seen as follows. Note that each addition to the daily schedule is presented in green font and unfortunate mishaps or cancellations with red.

Table 1: Proposed Work Plan

Dates	Mon. 23/04	Tues. 24/04	Wedn. 25/04	Thurs. 26/04	Frid. 27/04
Activity	**Visit Launch:** Meeting with colleagues / Short presentation of their work / getting acquainted with the polarimeter	**Analogue Electronics mini workshop**[i]**:** Introduction to *electric field – particle charge* sensory systems	**Dust electrification seminar:** Presentation of our progress / Extensive discussion / meeting with prominent astronomer Dr. James Hough	**Particle orientation seminar:** Extensive discussion for oriented dust particles / Visit the new Laser-spectroscopy laboratory Short visit in the Bayfordbury Observatory[ii]	**Visit End:** Team Meeting and informative Presentation for the D-TECT project first experimental campaign Evaluation of used data processing methods / Dust particle orientation
Person Responsible	Prof. Ulanowski	Prof. Ulanowski, Dr. Smith H. & Ms. Kezoudi M.	Ms. Daskalopoulou V.	Light scattering team, Dr. Tatarov B.	Prof. Ulanowski, Ms. Daskalopoulou V.

Starting from the first day on the 23rd, I got acquainted with the department spaces and met with prof. Ulanowski and his colleagues, whose scientific interests cover a variety of atmospheric research fields. Thereafter, I was guided to the main laboratory installment, where I had the chance to investigate the engineering arrangement of a new UAV multicopter, designed and tested by a highly promising PhD student of the Department. The specific drone will be used for multiple field measurements, as it can deploy a maximum payload of 1 Kg, tested to fly vertically to over 1 km but capable of reaching an estimated 2 km and at the moment undergoing tests in order to accommodate a newly designed Optical Particle Counter (OPC) sensor, developed and tested solely by the same team.

To this point, I would like to add that the CACP team is highly active in the theoretical and technical implementation of meteorological radiosondes since 2009. Along with the sondes system, there are several sensors constructed, calibrated and tested by the team even concerning atmospheric electric field and electric charge measurements, with the most nominal one being the sensor described in detail by Nicoll K. [1] and used for the charged dust measurements over Cape Verde island in 2009 [2]. Throughout the entire first day, there were several discussions with prof. Ulanowski concerning the interpretation of Potential Gradient (PG) measurements from the Field Mill (FM) installed in the ACTRIS

station of Finokalia Crete. The day's capstone was the meeting with a prominent and highly active applied astronomer Prof. Bill Martin, who will be kindly providing us with a sun polarimeter he personally designed and will be used to detect changes in the polarization state of the incident light when observing the sun through a dust plume.

On to the second day of the visit, prof. Ulanowski kindly provided information on a monodisperse aerosol generator held in the premises of the Atmospheric Analysis laboratory and also demonstrated the capabilities of their novel Small Ice Detector (SID) probe, part of the family of wing-mounted spatial light-scattering instruments that are designed to capture in situ data relating to the sizes, shapes, orientation and abundance of individual cloud particles such as droplets, ice crystals, and aerosol particles. Following the above, there was an extensive workshop on the electronic parts of the designed OPC sensor with the guidance of Dr. Smith and Ms. Kezoudi, but also I got to participate in the implementation of a dry-column tube for the final calibration tests of the instrument.

On Wednesday the 25th, I got the chance to be invited to give a seminar talk within the Department related to the work progress that is undertaken during my first year in the National Observatory of Athens as a research fellow and PhD student. The talk mainly outlined the theoretical background of my work on atmospheric electricity, presented our findings concerning the electric field strength variations during severe dust events in Crete, and also discussed the possibility of detecting oriented dust particles through dichroic extinction observations from the telescope mounted polarimeter in the observatory of Skinakas (Crete). The feedback from the audience, although multidisciplinary, was quite enthusiastic and was also topped with meeting the highly esteemed British astronomer Prof. James Hough, principal scientific investigator in the implementation of the PlanetPol [3] sensitive polarimeter back in 2005.

Continuing the planned activities for the visit, the 26th was dominated by extensive discussions with the Light Scattering and Radiative Processes (LSRP) team of CACP. Researchers from this area have been engaged for nearly thirty years in the theory and application of laser light scattering to non-destructive measurement and characterization of microparticles and living cells. Optical trapping and electrodynamic levitation techniques have also been developed and refined (e.g. through work on beam theory and theoretical optics) to support fundamental experimental investigations of particle scattering phenomena. Prof. Ulanowski demonstrated in full detail the capabilities of the electrodynamic levitation instrumental array, developed in the Department. Electrodynamic levitation is a technique for non-contact trapping of microparticles using electric fields. The particles are charged and held stationary using a combination of static (DC) and oscillating (AC) electric fields. In the specific laboratory, it is used to primarily trap various atmospheric particles so that their light scattering properties can be measured, focusing mainly on ice particles. To circumvent various difficulties associated with studying real ice in the laboratory, prof. Ulanowski discussed the use of simulated ice crystals, or ice analogues - particles with shape, size and refractive index resembling those of water ice. These include simple shapes (e.g. hexagonal columns or plates) as well as complex ones (rosettes or aggregates). Lastly, the need for extension of this work on other particle types, such as coarse mode mineral dust particles, was also highlighted.

After the light scattering seminar, Dr. Tatarov kindly provided insight on the newly developed Laser-spectroscopy laboratory under the auspices of a Marie-Curie grant and the University of Hertfordshire infrastructure. The experiments focus on light-scattering processes which are used to identify specific properties of atmospheric gases and particles. In the first stage, they target Raman spectroscopy and fluorescence phenomena as a primary source of signals from aerosol pollution for the purpose of

identification of chemical components in aerosol.

Concluding my visit in the UH, I was asked to give an extra talk on Friday morning and participate on the scientific team meeting. The presentation, mostly, revolved around the D-TECT project specifics and had more of an informative nature over the first experimental campaign of the project, which is planned for mid-June 2018 in the Antikythera Island. Since, I administer the campaign organization and many of our colleagues from UH will be participating, it was helpful for them to know the specifics and also openly discuss the possibilities we have for collaboration. Moreover, this extensive meeting offered, apart from administrative guidelines, a chance for us to review our different implementation of the electrometer/electric charge sensors and gain insight on the preferable designs by prof. Ulanowski. All in all this visit was a perfect opportunity to familiarize with basic atmospheric electricity and particle scattering concepts, to collaborate with highly esteemed researchers from various backgrounds and gather adequate theoretical background to be able to boost my ongoing research.

3. Quick Review of the scientific outcome, results and future considerations

In order to have a more comprehensive and concise view point, the following table (Table 2) provides in short detail the achieved goals during this scientific visit, along with some considerations on future collaborations with the members of CACP.

Table 2: Shortlist of the visit outcome, results and future collaborations

SHORT TERM VISIT in the UH						
Scientific Results	**i.** Interpretation of the **Potential Gradient (PG)** Measurements over Crete	**ii.** Interpretation and further processing of previous **electric charge measurements** during the Pre-TECT campaign	**iii.** Quantification of **cloud driven variations** in the PG with the collocated retrievals of the PollyXT[iii] lidar	**iv.** Scientific guidance over the **implementation of novel airborne micro-sensors**[1], MEMS electrometers and electrode based sensors[2]	**v.** Highlight the need to measure the **preferable fine-to-coarse** dust particle ratio for the fortification of the Triboelectricity hypothesis	**vi.** Knowhow transfer from the UH to further operate the polarimeter and obtain oriented dust signature through polarimetric measurements
Outcome	Potential expansion of our Field Mill network over the island of Antikythera	Redesigning of the existing sensor board, as the one shown in Nicoll et. al 2012	Potential trend during dust events where the plumes act as CCN	Collocated measurements of the electric field strength, ionospheric current and particle surface charge	Establish the link between theoretical considerations of D-TECT and observations	Enforce the novel D-TECT hypothesis of dust orientation

[1] http://www.mdpi.com/1424-8220/18/1/286/htm, http://www.mdpi.com/1424-8220/18/3/870/htm
[2] https://aip.scitation.org/doi/10.1063/1.5011177

Future Collaborations	With **Prof. Ulanowski** for the further calibration of the acquired instrument and reinstallation of the old one in Antikythera (*upcoming **first experiment of D-TECT**, expected in September 2018*)	Collaboration between **Prof. Ulanowski**, **NOA** and **Prof. George Hloupis** for the improved charge sensor	Collaboration with **Dr. Matthias Tesche**, **Dr. Helen Smith** & **Ms. Maria Kezoudi** for the OPC launches	With **Prof. Hloupis, Dr. Nikos Kalivitis** and **Prof. Ulanowski** for the implementation of such sensory systems (again utilized and tested on the upcoming campaign)	With **Prof. Nikos Mihalopoulos** and **Dr. Nikos Kalivitis**, for the in-situ measurements	With **Prof. Bill Martin** and **Dr. Alexandra Tsekeri** to calibrate, test and install on a fully automated scheme the sun polarimeter

I hope the committee finds my visit and subsequent report highly relevant to the Electronet activities and favors the finalization of the internal processing of this STSM grant.

References

[1] Nicoll, K.A. Surv Geophys 33: 991, 2012.

[2] Nicoll, K.A.,et al., Environ. Res. Lett., 6, 014001, 2011.

[3] Hough J. H. et al., Publications of the Astronomical Society of the Pacific, 118: 1302–1318, 2006

APPROVAL OF THE SENIOR RESEARCHER OF THE HOST INSTITUTE

Joseph Ulanowski

APPROVAL OF PHD PRINCIPAL SUPERVISOR

DATE: 11 / 05 / 2018

[i] Rescheduled from Wednesday to Tuesday morning

[ii] Unfortunately cancelled due to unfavorable weather conditions

[iii] http://polly.rsd.tropos.de/?p=lidarmenues&Ort=13