NMG\R2\170137

Dynamics in crowded suspensions of colloidal clusters

Laurati, Marco|University of Manchester

Funding sought	**£11,810.00**
Project start/end	**5 Mar 2018 - 4 Mar 2020**

1. Eligibility Criteria

Please confirm whether you meet the eligibility criteria for the programme as follows:

Do you and your co-applicant hold a PhD or equivalent research experience?

> Yes

Do you and your co-applicant hold a permanent or fixed-term contract in an eligible university or academic research organisation that spans the duration of the project?

> Yes

Is the lead applicant currently based overseas (i.e. not in the UK) and the co-applicant based in the UK?

> Yes

Have you held or do you hold an International Exchanges or Newton Mobility Grant award?

> No

Is this a new collaboration?

> Yes

Please note a new collaboration in this case is a collaboration that should be based on a single project involving (or lead by) the lead applicant (Overseas based researcher) and the co-applicant (UK based researcher).

2. Contact Details

Your contact details have been completed as you have entered these previously. The contact details of participants will automatically be recorded once you have invited them to partake in your application.
Please note the system defaults the contact type for participants as a collaborator. The Lead Applicant can amend the contact type for each participant using the edit button in the table below.

Professor Marco Laurati

Primary Applicant

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+52 1 4775801800 (Mobile)

mlaurati@fisica.ugto.mx (Work)

Oxford Road, Oxford Road, MANCHESTER, M13 9PL, Mexico
(Work)

Francisco Sastre

Collaborator

sastre@fisica.ugto.mx (Work)

Professor Christopher Hardacre

Collaborator

0161 3062672 (Work)

c.hardacre@manchester.ac.uk (Work)

School of Chemical Engineering and Analytical Science,
University of Manchester, MANCHESTER, M13 9PL, United
Kingdom (Work)

Dr Alessandro Patti

University of Manchester

Co-applicant

https://orcid.org/0000-0002-7535-0000

01613064346 (Work)

alessandro.patti@manchester.ac.uk (Work)

Oxford Road, Oxford Road, MANCHESTER, M13 9PL, United Kingdom

Your organisation details have been completed as you have selected these previously. If your organisation is correct you will not need to do anything else.

University of Manchester

Oxford Road, Oxford Road, MANCHESTER, M13 9PL, United Kingdom (Work)

3. Lead Applicant Career Summary

Title of Current Position

Please state the title of your current position.

Professor of Physics

Current Employer

Please enter the official organisation name of your current employer.

Universidad de Guanajuato

Current Department

Please enter details of your current department name (e.g. Department of Astrophysics).

Departamento de Ingeniería Física

Country

Please select the country where your current employer is based.

Mexico

Current Position Start Date

Please enter the date when your current position started.

27/07/2015

Current Position End Date

Please enter the date when your current position is expected to finish.

31/12/2050

If you are on a permanent contract please enter 31 December 2050 as your end date.

Applicant Qualifications

Please list all your qualifications in reverse chronological order.

Since 08/2015: Principal Investigator of the project ”Effect of anisotropic particles on the transition to flow of colloidal glasses”, funded by the Agency for Support to Excellent Investigation of the University of Guanajuato

08/2013-07/2017: Principal Investigator of the project ”One and two-component colloidal glasses under mechanically

imposed stress", funded by the German Research Council (DFG)

03/2013: Awarded with the Young Researcher Prize of the SFB-TR6 German-Dutch Research network on "Physics of Colloidal Dispersions in External Fields"

07/2005: Doctor Degree in Physical Chemistry, University of Münster (Germany), thesis title "Phase Behavior and Interactions of PEP-PEO Star-Like Micelles", supervisor Prof. Dr. Dieter Richter

07/2001: Laurea (Master's Degree) in Physics, University of Florence (Italy), supervisor Prof. Cecilia Gambi.

Applicant Career History

Please list all of your appointments since your PhD and the dates in reverse chronological order, stating if part-time (and percentage part-time) when necessary.

Since 07/2015: Full Professor of the Department of Physical Engineering of the "División de Ciencias e Ingenierías", Universidad de Guanajuato, Campus León, México.

12/2010-06/2015: Lecturer at the Condensed Matter Physics Laboratory of Prof. Stefan Egelhaaf, Heinrich-Heine University Düsseldorf, Germany

06/2009-11/2010: Postodoctoral Research Fellow at LPMA CNRS/Rhodia Recherches et Technologies, Lyon, France and Material Physics Centre, San Sebastian, Spain, project title "Water Dynamics in Polyamides", in collaboration with Dr. Paul Sotta, Prof. Juan Colmenero and Prof. Arantxa Arbe

08/2005-05/2009: Postdoctoral research fellow with Prof. S. U. Egelhaaf, Heinrich-Heine University Düsseldorf, Germany. Project title "Non-linear Response of Colloidal Glasses and Gels to Shear"

List your Key and/or Relevant Publications

Please provide details of authors, titles and references of your best publications in refereed journals, in reverse chronological order. You should choose not only the best but also those most relevant to the application to support your case.

D. Heckendorf, K. J. Mutch, S. U. Egelhaaf and M. Laurati, "Size-Dependent Localization in Polydisperse Colloidal Glasses", Phys. Rev. Lett. 119, 048003 (2017).

M. Laurati, P. Maßhoff, K. J. Mutch, S. U. Egelhaaf, and A. Zaccone, "Long-lived neighbors determine the rheological response of glasses", Phys. Rev. Lett. 118, 018002(2017)

R. F. Capellmann, N. E. Maßhoff, B. Simon, S. U. Egelhaaf, M. Laurati and R. Castañeda-Priego, "Structure of colloidal gels at intermediate concentrations: the role of competing interactions", Soft Matter, 12, 9303 (2016).

M. Kohl, R. Capellmann, M. Laurati, S. U. Egelhaaf, and M. Schmiedeberg, "Directed percolation identified as equilibrium pre-transition towards non-equilibrium arrested gel states", Nat. Commun., 7, 11817 (2016).

T. Sentjabrskaja, E. Zaccarelli, C. De Michele, F. Sciortino, P. Tartaglia, Th. Voigtmann, S. U. Egelhaaf and M. Laurati, "Anomalous dynamics of intruders in a crowded environment of mobile obstacles", Nat. Commun., 7, 11133 (2016).

Please provide up to five of your best publications.

Field of Specialisation

Please enter details of your field(s) of specialisation.

Physics of Colloids and Polymers, Glasses and Gels, Rheology, Self-Assembly, Advanced Microscopy

Subject Group

Please select the subject group that most closely reflects your area of research from the drop-down menu below.

> Astronomy and physics

Summary of your Current Research

Please provide an outline summary of your present research.

> - Experimental soft condensed matter physics
> - Phase behavior of complex colloids, including colloidal clusters, DNA-coated colloids and thermo-sensitive colloids.
> - Rheology of colloidal dispersions, with a focus on glassy systems and gels
> - Microscopic investigation of structure and dynamics of sheared systems
> - Directed Self-Assembly of equilibrium and non-equilibrium structures.
> - Transport phenomena in synthetic and biological crowded environments
> - Phase behavior of microemulsions and micellar systems.
>
> Our organisation is #20 in the national ranking, with a strong group in Statistical Mechanics and an excellent subgroup in Soft Condensed Matter whose members have all an h-index>10 (Scopus) and are ranked among the top 2000 researchers in México (Webometrics).

Please also include a brief comment on the strength of your Organisation

4. Co-applicant UK Career Summary

Please enter your full name, including title below.

Dr Alessandro Patti

Title of Current Position

Please state your current position title.

Lecturer in Chemical Engineering

Current Employer

Please enter the official organisation name of your current employer.

University of Manchester

Current Department

Please enter details of your current department name (e.g. Department of Astrophysics).

School of Chemical Engineering and Analytical Science

Current Position Start Date

Please enter the date when your current position started.

01/01/2014

Current Position End Date

Please enter the date when your current position is expected to finish.

31/12/2050

If you are on a permanent contract please enter 31 December 2050 as your end date.

Co-Applicant Qualifications

Please list all your qualifications in reverse chronological order.

Universitat Rovira i Virgili - 2007
PhD (Chemical Engineering)

Universitat Rovira i Virgili - 2005
DEA in Chemical Engineering

University of Palermo - 2002
Master in Chemical Engineering

Co-Applicant Career History

Please list all of your appointments since your PhD and the dates in reverse chronological order, stating if part-time (and percentage part-time) when necessary.

Lecturer in Chemical Engineering.
University of Manchester
01-01-2014
PI in the EPSRC funded project EP/N02690X/1 on biaxial nematic liquid crystals of board-like particles. Co-I in the EU funded project MULTIMAT on the self-assembly of amphiphiles in hierarchical porous structures.

Post-doctoral Research Fellow with Prof Conxita Solans.
Institute of Advanced Chemistry of Catalonia (IQAC) – CSIC, Barcelona Spain
12/2010 - 11/2013
Project: self-assembly of surfactants in highly concentrated emulsions.

Post-doctoral Research Associate with Prof Marjolein Dijkstra.
Utrecht University, The Netherlands
11/2007 - 10/2010
Project: Nucleation of colloidal crystals; collective dynamics in colloidal liquid crystals.

List your Key and/or Relevant Publications

Please provide details of authors, titles and references of your best publications in refereed journals, in reverse chronological order. You should choose not only the best but also those most relevant to the application to support your case.

A. Cuetos, M. Dennison, A. Masters, and A. Patti, Phase Behaviour of Hard Board-like Particles, Soft Matter, 13, 4270-4732, 2017

A. Cuetos and A. Patti, Equivalence of Brownian Dynamics and Dynamic Monte Carlo Simulations in Binary Mixtures of Colloidal Fluids, Physical Review E, 92, 022302, 2015

M. Marechal, A. Patti, M. Dennison, and M. Dijkstra, Frustration of the isotropic-columnar phase transition of colloidal hard platelets by a transient cubatic phase, Physical Review Letters, 108, 206101, 2012

A. Patti, S. Belli, R. van Roij, and M. Dijkstra, Relaxation dynamics in the columnar liquid crystal phase of hard platelets, Soft Matter, 7, 3533, 2011

A. Patti, D. El Masri, R. van Roij, and M. Dijkstra, Stringlike clusters and cooperative interlayer permeation in smectic liquid crystals formed by colloidal rods, Physical Review Letters, 103, 248304, 2009

Please provide up to five of your best publications.

Field of Specialisation

Please enter details of your field(s) of specialisation.

Soft matter; Molecular Simulation; Self-assembly; Phase Behaviour and Dynamics of Colloids; Polymer Nanocomposites; Amphiphiles

Subject Group

Please select the subject group that most closely reflects your area of research from the drop-down menu below.

> Materials Science

Summary of your Current Research

Please provide an outline summary of your present research.

> I investigate the physico-chemical behaviour of Soft Matter systems with focus on their ability to self-assemble into complex supra-molecular mesophases. In particular, I apply Molecular Dynamics and Monte Carlo simulations to study the phase behaviour and dynamics of colloidal and polymeric systems, which have a high impact in many industrial formulations (e.g. cosmetics and packaging).
>
> I am especially interested in the self-assembly of anisotropic colloidal particles, being able to form liquid crystals (LCs), a state of matter that is largely employed in displays. Currently, I am focusing on how polydispersity can improve the stability of biaxial nematic LCs, which have very intriguing optical properties for advanced display applications, and how external stimuli influence the ability of colloids to switch between different LC phases.
>
> Our School was rated among the best Chemical Engineering departments in REF2014 with grades of 4 (30%), 3 (60%), and 2 (10%). The Multiscale Modelling Group, consisting of 8 academics, works on liquids, colloids, polymers and LCs and their industrial applications (paints, lubricants, nanocomposites). The group has access to excellent state-of-the-art computational facilities provided by the UM (>9,200 cores), is funded by EPSRC, BBSRC and EU, and has ongoing collaborations with industry (Unilever, Johnson Matthey, Akzo Nobel).

Please also include a brief comment on the strength of your Organisation

5. Research Proposal

Project Title

Please give the full title of your proposed project.

> Dynamics in crowded suspensions of colloidal clusters

Start Date

Please enter the proposed start date of the project.

> 05/03/2018

Activities must start no earlier than 4 months after the application closing date.

End Date

Please enter the proposed end date of the project.

> 04/03/2020

This must be either 3 months, 1 year or 2 years from the start date.

Subject Group

Please select the subject group that most closely defines the research area of the research proposal from the drop-down menu below.

> Astronomy and physics

Subject Area

Please select one or more subject areas that most clearly defines the research area of the research proposal from the subject sub-category list below.

> Condensed Matter (incl. soft matter, liquids and nano-materials)
>
> Physics (Experimental)
>
> Chemistry, materials

Research Aims

Please state your scientific aims.

> Colloidal clusters are aggregates consisting of a small number of spherical particles bound together. Their shape anisotropy make them ideal building blocks for the self-assembly of hierarchical superstructures with complex geometry and symmetry. The formation of these superstructures is strongly determined by the ability of the colloidal clusters to diffuse through the solvent, reorient themselves, self-heal eventual defects and collectively contribute to achieve the most stable configuration as predicted by Thermodynamics.
> As such, understanding the kinetics of organisation of these aggregates in suspension is crucial to assess the feasibility of formation of ordered superstructures. To this end, this project aims at investigating (i) the dynamics of colloidal

clusters in crowded suspensions and the interplay between translation and rotational motion; (ii) the occurrence of collective dynamics; and (iii) the presence of dynamical heterogeneities associated with structural heterogeneities. From a more fundamental perspective, we are also interested in (iv) addressing the dynamics of guest molecules moving within these colloidal nanomaterials, which actually show a degree of porosity tunable as a function of the colloidal building block's geometry.
In particular, the above-mentioned points (i-iv) are key to find, respectively, the time scales needed to form a colloidal superstructure, to which extent cooperative motion contributes to the structural relaxation (equilibration) of a colloidal superstructure, the origin of eventual structural defects, and the conditions that might lead to anomalous diffusion.
To achieve these aims, we will employ experimental and molecular simulation techniques that are detailed in the section below.

Lay Summary

Please provide a lay summary of your proposed project. This should be understandable by a layperson. Explain why you have chosen to work in this subject area and what it is about your proposed research that you find particularly exciting, interesting or important. If applicable, please also explain the potential impact or wider benefits to society of your research.

Colloids consist of nanoparticles suspended in a solvent. Unveiling the origin of the forces determining their behaviour is crucial to obtain materials with specific properties (e.g. porosity, refractive index, density) and for specific applications (e.g. adsorption, storage, sensing). Over the last decades, there has been a growing interest in understanding how colloidal particles repel or attract each other and how to control their ability to self-assemble into precise nano-structures with well-defined properties.

This self-assembling process is, however, a formidable challenge, especially due to the difficulty of incorporating, into their surface, specific patchy interactions, forces with a high degree of directionality. The intriguing potential to control the selectivity and directionality of their interactions makes patchy particles excellent candidates to design nano-structures. While this scenario discloses unique opportunities to boost revolutionary applications, from photonic to self-healing materials, efficient synthetic strategies to fabricate patchy particles in a high yield for large-scale production, are still at an embryonic stage.

An alternative approach relies on the aggregation of a small number of colloidal spheres, whose size and binding affinities can be easily tuned. The resulting clusters can self-assemble into large-scale superstructures, such as highly porous crystalline materials, percolating gel-like networks and ordered sheets.

Our interest is on investigating the kinetics governing the self-assembly of colloidal clusters in such superstructures. This will provide the fundamental understanding for the rational design of nanomaterials with specific properties (e.g. ability to encapsulate guest species) and optimise their performance in high-impact applications for our society (e.g. recognition and sensing).

Research Proposal

Please provide details of your research proposal in the field below.

In this project we will investigate the self-assembly of colloidal clusters into colloidal superstructures. We are particularly interested in ordered superstructures, which can provide peculiar optic properties and storage capabilities. We will focus on the role of the cluster dynamics in the self-assembly process that leads to the formation of these superstructures. The dynamics will be affected by the cluster shape (dimer, trimer, tetramer,...) as well as the cluster-cluster interactions, the cluster concentration and the characteristics of the solvent, in particular the viscosity. We aim at nailing down the role of each of these control parameters on the formation of superstructures with specific structural patterns of assembly. This will help defining directed self-assembly routes to obtain desired superstructures. For this purpose we will investigate dispersions of colloidal clusters of different shapes and concentrations, using solvents of different viscosity and eventually modifying their interactions through variation of the charge (by changing the amount of salt) or inducing depletion attractions (by adding polymers). We will combine confocal microscopy and differential dynamic microscopy experiments realized by the overseas partner (Universidad de Guanajuato, UG) with equilibrium and dynamic Monte Carlo simulations performed by the UK partner (University of Manchester, UM).

The project will specifically deal with the following aspects:

i- The study of the dynamics of individual colloidal clusters in concentrated suspensions during the process of self

assembly: We will characterize translational and rotational motions of clusters of different shapes and their interplay as a function of the control parameters, by determining the translational and rotational mean squared displacements of the clusters. This will clarify the role of the individual particle dynamics on the formed superstructures.

ii- The investigation of the collective dynamics: We will determine how the motions of different clusters correlate and how this affects the self-assembly and the final superstructure. To quantify the collective motions, we will use the collective intermediate scattering functions of the samples, extracted from experiments and simulations for different values of the control parameters.

iii- The presence and influence of dynamical heterogeneities, and their link to structural heterogeneities: Dynamical heterogeneities will be characterized through higher order dynamical correlation functions as well as the behaviour of subgroups of clusters. Due to the ability of determining coordinates and trajectories of individual particles and clusters both in experiments and simulations, we will be able to define subgroups based on their dynamical activity and local structural arrangements.
-
iv- Transport properties within the formed superstructures: The self-assembled superstructures are not space filling and may present different degrees of porosity. We will investigate the transport of small particles and molecules through the superstructure, to test the effects of confinement and reveal the possible presence of anomalous diffusion, depending on the particle size and the available free volume within the matrix. This topic is of interest to understand the dynamical behaviour in crowded environments.

Your proposal should also include an outline of the nature and purpose of your research project including a description of the experimental methods and techniques to be used.

Outline of Data Management and Data Sharing Plan

If the proposed research will generate data that is of significant value to the research community, then please provide details of your data management and sharing plan.

Two datasets will be generated: experimental (confocal microscopy) and computational (molecular simulation) data.

All data will be made available to the public. The most relevant data, such as functions describing the structure of the systems (e.g. distribution functions, structure factors) and their dynamics (e.g. mean square displacements, scattering functions), will be also published in specific journals. Input files to reproduce simulations (e.g. configuration files and particles' trajectories) and details on the experimental set up will be included in the universities repositories.

Our results will be disseminated in peer-reviewed journals supporting open access. To maximise visibility, our publications will be deposited on Pure, the UM's open-access database.

All data will be made available as soon as this work will be submitted for publication or soon after. To make the data output accessible to a wider audience, links to repositories will be added to our publications and personal web pages, where a description of the project will be given.

There are no existing commercial interests or conflicting interests of any sort and therefore the complete set of data can be made publicly available.

Participants

List other project participants from both teams, their current academic role/post and why you wish to include them on the project.

a) UG

- Alejandro Gil Villegas (AG), Professor. Expertise in statistical mechanics and molecular physics with a focus on adsorption kinetics of fluids. He will perform theoretical calculations of gas adsorption in the nanostructures, formed by self-assembly of colloidal clusters. He will explore also the parallel between colloidal clusters and molecular species.

- Mayra Alejandra Lara Peña (MP), PhD Student. Skilled in confocal microscopy experiments on colloidal systems and with a background in simulations. She will perform experiments on the assembly of colloidal clusters and will learn how to simulate the process through the collaboration with AP.

b) UM

- Carlos Avendaño (CA), Lecturer. Expertise in phase behaviour and self-assembly of colloids in the bulk and under confinement. He will run Monte Carlo simulations to equilibrate systems of colloidal crystals in the bulk and their sedimentation onto solid substrates under the effect of gravity.

- Flor Siperstein (FS), Reader. Expertise in adsorption of fluids in porous solids. She will run Monte Carlo simulations to study the N2 and CO2 adsorption in the nanostructures, formed by self-assembly of colloidal clusters, to characterise their porosity.

Participants include PhD students, post-doctoral researchers and any other research staff members from both teams.

Benefits to individuals/institution

Please describe clearly the planned outcomes and any potential benefits that will result from the proposed collaboration for you, the co-applicant and the respective organisations.

Outcomes.
Publication in a high-impact journal (e.g. PRL) as a proof of evidence for a larger grant application (e.g. EPSRC standard).

Benefits.
Experimental/computational collaboration and distinct areas of expertise (ML: glasses; AP: liquid crystals) will promote know-how exchange to better tackle the self-assembly of colloidal clusters by alternative perspectives and techniques.

ML has recently established a Soft Matter Laboratory at UG and will benefit of the collaboration with simulators/theorists, also as a mean to form students in both aspects.

AP has recently joined the Mexican Soft Condensed Matter Network, established under the auspices of CONACYT and coordinated by UG. This project will promote his research within this network and facilitate recruitment of human resources for his group.

Currently, more than 100 Mexican students, the majority of whom are PhDs, are studying at UM, which maintains working links with CONACYT and other Mexican sponsors. By acting as UM ambassador, AP will contribute to consolidate this relationship and students exchange between the two countries.

Simultaneous use of experimental and computational techniques will help unveil the kinetics of colloidal clusters self-assembly and more easily bridge the gap between fundamental science and applications, thus adding value to this project.

Please comment on how the award will contribute to the transfer of knowledge and research capabilities to the overseas partner, the added value of the collaboration, and the intentions for sustaining the partnership in the longer term.

Benefits to UK

Describe any potential benefits to the UK, and UK research that will result from the proposed project.

The mission of this research is to employ computational and experimental knowledge to understand the kinetics of self-assembly of colloidal crystals in advanced materials for gas adsorption and storage, catalysis, recognition and sensing. By pooling of skills, this international collaboration will be key to create the conditions to attract industrial partners willing to explore our fundamental research and, on a longer term, facilitate its transfer to the market. This would represent an important benefit for the UK fundamental research in colloids as well as its economy. As a matter of fact, our research and its practical applications fall within the area of Advanced Materials and Nano-Technology, one of the Eight Great Technologies supporting the UK science strengths and the business capability of the UK material-related industries (annual turnover of £197bn [1]). Additionally, the mission of this project is strongly aligned to the EPSRC research priority areas of Soft Matter and Colloid Science and Computational and Theoretical Physical Sciences.

[1] UK Government, Eight great technologies: infographics, 2013.

Benefits to Overseas Country

Describe any potential benefits to the overseas country and/or country of origin that will result from the proposed project.

> This project will benefit the growth of the rapidly developing area of soft condensed matter at the University of Guanajuato, in particular the topic of colloidal science. The expertise of the UK partner in simulations and theory of complex colloids will be transferred to the overseas partner, complementing the existing experimental skills. The proposed collaboration will in particular support the interdisciplinary formation of PhD students from the overseas country.
> The topic of the proposal has potential important applications in crucial sectors of technological innovation, mostly concerning the development of new materials. Due to the investments and establishment of several multinational enterprises of the automotive, aerospace and home and personal care sectors in México, and especially in the area called "Bajio" to which the state of Guanajuato belongs, technological innovation is at the forefront of the national priorities and one of the key elements to promote economic development and social welfare.

Please how describe how the research will contribute to promoting economic development and social welfare of the country to benefit the wider society

6. Use of Animals in Research

Does your proposal involve the use of animals or animal tissue?

> No

7. Financial Details

Please specify the duration of your project.

> 2 years

Budget Table

Please define the proposed budget for your project in the table below:

Budget heading		Budget	Total
Consumables (inc. fieldwork):			
Consumables	Cost	£200.00	£200.00
Subsistence:			
Subsistence	Cost	£6,000.00	£6,000.00
Travel:			
Travel	Cost	£5,610.00	£5,610.00
Total	**Cost**	**£11,810.00**	**£11,810.00**

Justification for Consumables (incl. fieldwork)

Please fully justify your request for consumables, including expenses for fieldwork.

> Poster printing: £200

Justification for Subsistence

Please fully justify your request for subsistence.

> Below, we include costs for accommodation (estimated at £40/day in UK and £20/day in Mexico), subsistence (£15/day in UK and £7.5/day in Mexico) and internal travelling (£2/day in UK and £1/day in Mexico) for the six visits planned within this research collaboration.
>
> Gil Villegas: 2 weeks, March 2018, UK, £800;
>
> Avendaño: 2 weeks, June 2018, Mexico, £400;
>
> Laurati: 1 month, July 2018, UK, £1600;
>
> Lara Peña: 1 month, July 2018, UK, £1600;
>
> Patti: 1 month, August 2019, Mexico, £800;
>
> Siperstein: 1 month, December 2019, Mexico, £800.

Justification for Travel

Please provide justification for the amount requested.

> Flight connections between Manchester and León are at around £900 per return ticket. Taxi connections between the airports and the main accommodation residences are estimated at £25 one way in the UK and £10 one way in Mexico. Therefore, the estimated travel costs are £950 per visit to the UK and £920 per visit to Mexico.
> The total budget requested is £950x3 + £920x3 = £5,610.

9. Head of Department Support

Head of Department Contact Details
Please completing the following:

Full Name including Title	**Full Name including Title** Professor Chris Hardacre
Current Position	**Current Position** Head of School
Department	**Department** School of Chemical Engineering and Analytical Science
Host Organisation	**Host Organisation** University of Manchester
Email Address	**Email address** c.hardacre@manchester.ac.uk

Head of Department Support
Please confirm whether the applicant will be provided with adequate space and access to resources within your department.

Yes

10. Head of Department Overseas Support

Head of Department Contact Details
Please completing the following:

Full Name including Title	**Full Name including Title**
Current Position	**Current Position**
Department	**Department**
Host Organisation	**Host Organisation**
Email Address	**Email address**

Head of Department Support
Please confirm whether the applicant will be provided with adequate space and access to resources within your department.

- Yes
- No