

An Oxford New College-Johns Hopkins Centre for Cosmological Studies

Joseph Ivor Silk

**2011 Balzan Prize for The Early Universe
(from the Planck Time to the First Galaxies)**

Balzan GPC Adviser: Bengt Gustafsson

Project Directors: Chris Lintott (Project Director); Adrienne Slyz, Marc Kamionkowski, John March-Russell (Advisory Committee)

Researchers: Alissa Bams, Melanie Beck, Razieh Emami Meibody, Seyda Ipek, Suvodip Murkherjee, Joakim Rosdahl, Julien Devriendt, Mark Richardson, John Chis olm, Ricarda Beckmann, Cora Uhlemann, Rebekka Bieri, Emanuele Castorina, Rajul Datta, Francesco De Bernardis, Joanna Dunkley, Zachary Dugan, Anastasia Fialkov, Farhang Habibi, Mariele Motta, Rafael Batista, Cliff Johnson

Affiliated Institution: New College, University of Oxford

Period: 2013-

Website: <http://balzan.new.ox.ac.uk/home.shtml>

Joseph Ivor Silk is Professor of Physics at the Institut d'Astrophysique at the Université Pierre et Marie Curie in Paris, Homewood Professor in the Department of Physics and Astronomy at Johns Hopkins University in Baltimore, and Senior Fellow in the Beecroft Institute of Particle Astrophysics and Cosmology of the Department of Physics at the University of Oxford. Silk has designated part of his Balzan research funds for the creation of a Centre for Cosmological Studies based at New College Oxford and at the Department of Physics and Astronomy at the Johns Hopkins University in Baltimore. It also involves the Oxford University Department of Physics and the Institut d'Astrophysique of the Université Pierre et Marie Curie-Sorbonne Universities in Paris. The Centre's goal is to provide Balzan grants for young researchers in cosmology in frontier areas of research that are consistent with the scientific themes supported by the Centre, and to establish international links involving leading young researchers to develop scientific interactions and collaborations that will benefit their careers as well as enhance the scientific life of the partner institution.

The first grants were awarded in the autumn of 2013 to Visiting Junior Research Fellows hosted at the institutions mentioned above. During the first three years of operation of the Oxford New College-Johns Hopkins Centre for Cosmological Studies, some twenty-four young researchers were hosted at the participating institutions for periods of up to two months each. The researchers were selected from a large field of candidates, and chosen because of their outstanding science potential and their interactivity with cosmology faculty at the participating institutions. The goal is to choose brilliant young researchers who will boost their careers by developing new collaborations. Several visited New College, while others were at the Johns Hopkins University at IAP, Paris.

The New College Balzan fellows initiated a series of Balzan Conversations, a well-attended informal discussion about their research, to which the New College fellowship as well as undergraduate and postgraduate physics students were invited. New College Balzan guests also participated in many high table and lunchtime discussions with fellows. Their research interests spanned subjects including the origin of cosmic structure and the fossil radiation echo from the Big Bang.

An indication of the success of the programme may be gleaned from the fact that nearly 50% of the researchers were doctoral students and one-third were female, all first-choice candidates and highly likely to continue successful careers in research boosted by the opportunity offered by the Balzan grant to Silk for enabling them to become better acquainted with leading institutions.

2015 candidates: Alissa Bams, a postdoctoral student at the Adler Planetarium in Chicago, visited the University of Oxford to work on issues of object retirement for the zooinverse project, Disk Detective, whose main goal is to find signs of planet formation (like dusty asteroid belts) around nearby star systems. Rafael Batista, a PhD student at the University of Hamburg, went to the University of Oxford to work on a project on ultra-high energy cosmic rays and the magnetized cosmic web, which resulted in an article to be submitted for publication and results presented at invited seminars at the Federal University of Rio de Janeiro, Brazil, and the University of Oxford. Melanie Beck, a PhD student at the University of Minnesota, visited the University of Oxford to develop an innovative galaxy morphology classifier utilizing human and machine intelligence to address the issue of scalability when considering the next generation of massive astronomical datasets presented in surveys such as the LSST and Euclid. To accomplish this she proposed reinventing the Galaxy Zoo classification system by

incorporating various machine learning algorithms with users' visual classifications to increase efficiency and scalability and by implementing a novel 'filtering' approach whereby human and machine classifiers would be fully integrated and recursive. She expects to publish on this research in 2016. Raziieh Emami Meibody, a PhD student at the Institute for Research in Fundamental Sciences in Iran, visited Johns Hopkins University, and worked under the supervision of Professor Marc Kamionkowski on the following projects: cosmological constraints to an axiverse-inspired quintessence field; probing the scale dependence of non-Gaussianity with spectral distortions of the cosmic microwave background (published in 2015); and clustering fossil from primordial gravitational waves in anisotropic inflation (published in 2015). Seyda Ipek, PhD student at the University of Washington, went to the University of Oxford to investigate the dynamics of oscillations in an attempt to find out where all the antimatter in the universe is. She developed a testable model of the history of our Universe when the matter-antimatter asymmetry was produced. Suvodip Murkherjee, a PhD student at the IUCAA in India, visited Johns Hopkins University to work on the problem of hemispherical asymmetry from bubble collisions. Joakim Rosdahl, a postdoctoral researcher at Leiden University, had two aims in visiting the University of Oxford to work with the group of Adrienne Slyz and Julien Devriendt. The main one was to study the effects of stellar radiation feedback in galaxy evolution by using a suite of cosmological zoom simulations. This work has led to the development of a parallel project with Mark Richardson at Oxford Astrophysics and John Chisolm at the University of Wisconsin comparing real observations in order to understand what physical models in their simulations might produce the best matches, with publications expected in 2016. The secondary aim was to work with Ricarda Beckmann on studying the role of photoionisation and radiation pressure around active galactic nuclei. Cora Uhlemann, a postdoctoral researcher at LMN in Munich, visited the Institut d'Astrophysique in Paris to carry out research focused on physically understanding, analytically modelling and accurately predicting the large scale structure of the universe, that is, how the universe evolved from a nearly uniform initial state into a stage featuring structures on various scales, from stars over galaxies to clusters. Her work involves theoretical aspects that are intimately connected to both numerical measurements obtained from N-body simulations and astrophysical observations provided by galaxy surveys, which make it possible to extract and constrain cosmological parameters. The preprint for a related article is listed below.

2014 candidates: Rebekka Bieri, PhD student at the Institut d'Astrophysique in Paris, visited Johns Hopkins University to study the impact of Active Galactic Nuclei (AGN)

feedback on the host galaxy and the precise communication mechanism between AGN and the galaxy's gas, and to investigate positive AGN feedback. Emanuele Castorina from the SISSA International School for Advanced Studies in Trieste, Italy, went to the Institut d'Astrophysique in Paris to report on quantitative predictions for cosmic voids statistics. His specific contribution consisted in extending analytical tools typically used to describe overdense regions to voids, systematically taking into account the number of objects out of which voids are defined, and developing a model giving the right abundances and shapes of voids as a function of size for high enough densities. This represents the first attempt to consistently describe voids statistics as a function of the number of density of galaxies. Rajul Datta, graduate student at the Department of Physics at the University of Michigan, Ann Arbor, visited Johns Hopkins University in the USA to work on galaxy formation and evolution in the universe, namely, the detection of galaxies in the cosmic microwave background (CMB) maps from the currently observing Atacama Cosmology Telescope Polarization (ACTPol). Francesco De Bernardis, postdoctoral student at Cornell University, went to Oxford University to interact with the ACTPol collaboration group led by Professor Joanna Dunkley and to work in collaboration with Professor Silk on a project to determine the possibility of detecting variations from a black-body spectra in the frequency distribution of the intensity of the CMB. Zachary Dugan, a graduate student in the Department of Physics and Astronomy at Johns Hopkins University USA, visited the University of Heidelberg to investigate the relationship between super massive black holes, which reside at the centre of all galaxies, and their host galaxies (publication 2014). Anastasia Fialkov, Junior Research Chair Fellow at the International Center for Fundamental Physics of the École Normale Supérieure in Paris, went to Johns Hopkins University to do work on the distortion of the luminosity function of high-redshift galaxies by gravitational lensing. Focusing on how gravitational lensing affects the observable luminosity function of the distant sources, the main conclusion of Fialkov's work is that depending on the intrinsic properties of the background galaxies, gravitational lensing can significantly affect the observed luminosity function even when no obvious strong lenses are present. Farhang Habibi, postdoctoral researcher at the School of Astronomy, IPM, Iran, visited the Institut d'Astrophysique de Paris to develop methods to test the accuracy of models of modified gravity. Cliff Johnson, graduate student in the Department of Astronomy at the University of Washington, went to Oxford University to collaborate with the Zooniverse citizen science organization and to complete work on the Andromeda Project catalog publication. Mariele Motta, postdoctoral researcher at the University of Heidelberg, went to Oxford University to do work on theories of gravity and how gravity affects the dynamics of galaxies.

Publications are planned for the near future for the projects of Datta and De Bernardis. For further information on 2013 awardees and their publications, see the third edition of the *Overview* on the International Balzan Foundation website: <http://www.balzan.org/en/prizewinners/joseph-ivor-silk/research-project-silk>.

Publications

- Desjacques, V., J. Chluba, J. Silk, F. De Bernardis, O. Doré. Submitted March 2015. Detecting the cosmological recombination signal from space. arXiv:1503.05589.
- Dugan, Z., S. Bryan, V. Gaibler, J. Silk, M. Haas. 2014. Stellar signatures of AGN-JET-triggered star formation. *The Astrophysical Journal*. Vol. 796, no. 2. DOI 10.188/0004-637X/796/2/113.
- Emami, R., E. Dimastrogiovani, J. Chluba, M. Kamionkowski. 2015. Probing the scale dependence of non-Gaussianity with spectral distortions of the cosmic microwave background. *Phys. Rev. D* 91, 123531.
- Emami, R., H. Firouzjahi. 2015. Clustering fossil from primordial gravitational waves in anisotropic inflation. *Journal of Cosmology and Astroparticle Physics*. DOI 10.1088/1475-751/2015/10/043.
- Uhlemann, C., S. Codis, C. Pichon, F. Bernardeau, P. Reimberg. Submitted 17 December 2015. Back in the saddle: Large-deviation statistics of the cosmic log-density field. arXiv:151205793.