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
Advisory Committeee: Adrienne Slyz, Marc Kamionkowski, John March-Russell
Affiliated Institution: New College, University of Oxford
Period: 2013-
Website: http://balzan.new.ox.ac.uk/

Joseph Ivor Silk is at the Institut d'Astrophysique of the Pierre and Marie Curie-Sorbonne Universities in Paris. He is also Homewood Professor in the Department of Physics and Astronomy at Johns Hopkins University in Baltimore, Fellow at New College, and Senior Fellow in the Beecroft Institute of Particle Astrophysics and Cosmology of the Department of Physics at the University of Oxford.

Cosmology is in a golden age of discovery and has succeeded in capturing the attention of wide swathes of society that extend well beyond the confines of academia. Such questions as the origin of the Universe, the nature of its predominantly dark material, and the question of its future, fascinate the public at large, and succeed in attracting the brightest young minds into physics research. Yet a deeper understanding of what is meant by a science of cosmology, in the fuller reaches of these words, is in its infancy. It must involve astrophysics, physics, philosophy, and cosmogony, and tackle genuinely fundamental questions in cosmology.

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 Pierre and 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 among 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. In the five years of the Centre's existence, more than fifty early-career researchers have benefited from the fund's support to travel and to sustain collaborations at participating institutions of Oxford, IAP and the JHU. They come from every corner of the world and have ended up working on every continent.

The first grants were awarded in the autumn of 2013 to Visiting Junior Research Fellows hosted at the institutions mentioned above. 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.

Balzan Awardees 2021-2022

Matteo Braglia was a postdoctoral researcher at the Instituto de Física Teórica of the Universidad Autónoma de Madrid at the time. His research program aimed at advancing our understanding of primordial features and their observable consequences by addressing the following problems: conducting a systematic scan for features in cosmological data; preparing the ground for new data by developing suitable pipelines to compute relevant observables and analyze them; exploring features signatures in new observables, in particular the anisotropies of the cosmic neutrino and the stochastic gravitational wave background. Braglia's multi-disciplinary research program connects the fragmented pieces of the early Universe physics through observations at large, intermediate and smallest cosmological scales, thus leading to a deeper understanding of our universe.

Yun-Ting Cheng is a postdoctoral researcher at the California Institute of Technology. His research interests include intensity mapping, large-scale structure (LSS), extragalactic background light, and data analysis techniques. The project that Yun-Ting Cheng proposes works in collaboration with Ben Wandelt (IAP/CCA), Olivier DorDoré (JPL/Caltech), and Tzu-Ching (JPL/Caltech) on a new to probing the LLS directly from multi-band imaging data. After promising preliminary results, they plan to apply their technique to a more practical setup. Through Prof. Silk's Balzan research project funds, Yun-Ting Cheng would travel to the Institut d'Astrophysique, Paris (IAP), to foster collaboration on the project and to discuss various research topics with the cosmology community there.

Francesc Cunillera, a PhD student at the University of Nottingham, was hosted by the University of Oxford, where he worked with Roya Mohayee.

Johanna Hartke, a postdoctoral fellow at the University of Oxford at the time, worked on a project with Martin Bureau at Oxford.

Ruchika Kaushik of the Indian Institute of Technology, Mumbai, was hosted by John Hopkins University to work on a project with Roya Mohayee.

Nanoom Lee, was a PhD candidate in Physics (Cosmology) at New York University at the time. His research interests focus on understanding the structure and evolution of our universe by utilizing existing observational data such as Cosmic Microwave Background (CMB) and galaxy fluctuations, forecasting future redshift-space distortion, Dark Matter (DM)-baryon scattering, and 21cm fluctuations. He proposed a project of follow-up studies on Prof. Marc Kamionkowski's (Johns Hopkins University) recent research that calculates cosmological perturbations without the Boltzmann hierarchy, replacing it (all photon intensity and polarization multipoles from quadupole and higher) with just two iterative integral equations (IEs), thus offering an alternative method of calculation that may allow current state-of-the-art cosmological-perturbation codes to be accelerated. Once this project is completed, its results could be applied to study DM-baryon scattering.

Farnik Nikakhtar, a PhD student at the University of Pennsylvania at the time, proposed a project with Roya Mohayee at the Institut d'astrophysique de Paris.

Vivian Sabla, was a PhD candidate in Physics and Astronomy at Dartmouth College at the time. Her research focuses on building alternative models to solve cosmological tensions with three guiding questions. First, can all epochs of universal expansion be linked with a single cohesive theory? Second, how can cosmological data be used to inform the construction of models? And third, can cosmological tensions be solved with existing physics, or is cosmology in need of a complete reboot? Her proposed project would build on her research into comprehensive, data-driven cosmological model building. As she sees it, the problems faced by the standard model result from increased precision in cosmological measurements, suggesting that cosmological data, coupled with the wealth of new datasets yet to come, will require a more comprehensive, ambiguity-free model. Sabla's project would work with Prof. Marc Kamionkowski, whose research focuses on developing new methods of obtaining cosmological information from a variety of different current and upcoming observations.

Elizaveta Sazonova, PhD student at Johns Hopkins University at the time, went to the University of Oxford to work with Chris Lintott.

Francesca Scarcella, at the time a pre-doctoral researcher at the Instituto de Física Teórica of the Universidad Autónoma de Madrid, proposed a research project to be carried out at the Institute d'Astrophysique de Paris, with Marta Volonteri, an expert in the field of massive black hole (BH) formation, as host scientist. The purpose was to bring together advances in the computation of the dark matter (DM) spike profiles with Volonteri's expertise in order to progress towards an accurate description of the

spike under realistic intermediate-mass black hole (IMBH) formation scenarios. Points to be addressed included the identification of formation channels leading to relevant targets; the environmental conditions under which the formation occurs and how this can be taken into account in the modeling of the spike formation; the effects on the spike of the subsequent evolution of the system. Following the identification and examination of an interesting formation scenario, it will be implemented in a numerical framework, which would, for example, cover the evolution of the DM halo through these phases: the formation of the star, its collapse into a BH, and the subsequent growth of the BH through accretion. This will set the stage for a comprehensive paper to be published in the near future.

Avery Tishue, a PhD student at Dartmouth College at the time, proposed a project with Marc Kamionkowski at Johns Hopkins University.

Kevin Wolz, a PhD student at the International School of Advanced Studies, Trieste, Italy, proposed a project with David Alonso and Susunna Azzoni at the University of Oxford.

Balzan Awardees 2023

Andrew Eberhardt, fellow at the Kavli Institute for the Physics and Mathematics of the University of Stanford, devised a project to work with Julien Devriendt of the University of Oxford.

Jindra Gensior, a postdoctoral researcher at the Institute for Computational Science at the University of Zurich in Switzerland, proposed a project at the University of Oxford with Martin Bureau.

Lukas Kammerer of the University of Applied Sciences, Upper Austria, spent four weeks at the University of Oxford as part of the Balzan Fellowship. He worked together with Pedro Ferreira, Professor of Astrophysics at the Department of Physics on very similar approaches to deterministic symbolic regression. More specifically, their project entailed the extension of existing methods for deterministic symbolic regression and on the modelling of an efficient, differentiable emulator for the non-linear power spectrum of the matter distribution in the universe in the field of cosmology.

Sarah Libanore of the Ben Gurion University of the Negev proposed a project with Marc Kamionkowski at Johns Hopkins University.

H.V. Ragavendra, a postdoctoral fellow in astronomy and astrophysics at the Raman Research Institute, India, worked on a project at the Institut d'Astrophysique with Joseph Silk.

Francisco Rodriguez Montero of the University of Oxford proposed a project at the Institut d'Astrophysique de Paris with Yohan Dubois.

Shohei Saga of the Istitut d'astrophysique di Paris, proposed a project at the University of Oxford with Julien Devriendt.

David Sanchez Cid, doctoral researcher at CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas), applied for a project to work with David Alonso at the University of Oxford,

Eleni Tsaprazi, a PhD candidate at Stockholm University at the time, traveled to the University of Oxford to work with Julien Devriendt. Her research focuses on Bayesian field-level analyses of galaxy clustering.

Tariq Yasin, a graduate student at the University of Oxford, went to the Institut d'Astrophysique de Paris to study with Yohan Dubois.