

Non-equilibrium, the most fascinating field of physics

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This thematic issue of CONTRIBUTIONS TO SCIENCE is devoted to one of the most fascinating fields in modern science, the study of non-equilibrium systems. Non-equilibrium pervades nature. From a galaxy to a bacterium, all systems are out of equilibrium to some extent. The understanding of non-equilibrium phenomena has been a persistent goal in physics since the emergence of thermodynamics back in the 19th century, its influential role far reaching other fields such as chemistry and biology. Non-equilibrium physics is key in many widespread disciplines such as astrophysics, atmospheric sciences, condensed matter physics, chemical physics, economy, evolutionary biology to cite a few.

Physicists might say that a system is out of equilibrium when there are net currents of any physical conserved quantity such as energy, charge, momentum, etc. In contrast, equilibrium systems are those where such currents vanish. Since our universe is continuously expanding, strictly speaking everything contained in it is out of equilibrium, the equilibrium assumption being only an approximation (and a very good one in many cases). However, and despite of its importance, our current understanding of non-equilibrium, albeit large, still remains incomplete. An underlying unified picture is still missing, fundamental results being still seen as partial results describing phenomena under specific conditions (e.g., the fluctuation-dissipation theorem). If it were not for the sole existence of the second law of thermodynamics we could say that fundamental laws for non-equilibrium are still to be discovered.

In view of these facts we found timely to setup a special issue for CONTRIBUTIONS TO SCIENCE gathering papers on a few selected topics currently investigated by physicists in the Catalan community. The papers cover different areas of the non-equilibrium science such as non-linear phenomena, disordered systems, statistical thermodynamics, fluid dynamics, materials science, biophysics and neuroscience. Nowadays physics has reached such a degree of maturity to become a highly

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interdisciplinary science, being applicable to the most diverse problems and contexts. In turn, we are witnessing a situation where physics steadily delves inside the most unexpected niches of knowledge that, until a few years ago, remained unfit to it. There is a long way ahead of us for such interdisciplinary quest and new unexpected fundamental discoveries in physics might emerge in the coming years. If this holds true then non-equilibrium physics surely remains the right area to grind. We hope this recollection of selected articles in this exciting area will contribute to stimulate

further scientific discussions and collaborations within our small but highly active research community.

It remains to us acknowledging those who have made possible this special issue, particularly physicist and historian of science Dr. Emma Sallent Del Colombo and Prof. Ricard Guerrero, the editor-in-chief of CONTRIBUTIONS TO SCIENCE. Their willingness and concerted effort in preparing this volume are definitely contributing to the visibility of one of the most active research areas in the Catalan physics community. 🟩

About the images on the first page of the articles in this issue. Articles of this thematic issue of Contributions to Science show in their first page one photograph made by Prof. Douglas Zook (Boston University, Boston, MA, USA) from his book *Earth Gazes Back*. Those fourteen ephemeral images were reflections on glass windows of different landscapes in the cities of Kraków, Prague and Boston. Multiple angles of light beams dance across the air, reflecting the ever-changing reality around us. The editors of this issue believe that those photographs represent very appropriately the ever-changing reality conceptualized by one of the most fascinating fields in modern science: the “Non-equilibrium physics”. (See also the article “Reflections: The enduring symbiosis between art and science,” by D. Zook, on pages 249-251 of this issue [<http://revistes.iec.cat/index.php/CtS/article/view/142178/141126>]). This thematic issue can be unloaded in ISSUU format and the individual articles can be found in the Institute for Catalan Studies journals’ repository [www.cat-science.cat; <http://revistes.iec.cat/contributions>].