



Aspen Institute Italia Award 2020

A microlaser generating twisted light for optical communication systems of the future

Orbital angular momentum microlaser¹ - A semiconductor laser of micrometric size that produces twisted light by exploiting an “exceptional quantum point”: this is the study that won the fifth edition of the [Aspen Institute Italia Award](#) for collaboration and scientific research between Italy and the United States.

The research stems from the joint work of seven scientists belonging to three different scientific organizations. It represents important progress in the physics and technology of integrated semiconductor lasers. The orbital angular momentum laser conceived and manufactured by the US-Italy team is a key element in the generation of twisted light, which can revolutionize the current optical communication systems and allow the transmission of information at very high speed – something that is necessary to sustain the forthcoming fourth industrial revolution.

The authors of the research project are the following:

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The originality of the research is the ideation and realization of a miniaturized laser. This miniscule laser – of just a few micrometers – operates in a so-called exceptional quantum point, where the emitted light twists rapidly in propagation. The light oscillates at different frequencies (colors), and for each frequency it can be twisted a limited number of times, giving rise to a swirling wave (as in the vortices of water that form in a drain). An optical vortex carries what physicists call the orbital angular momentum of the photon. Vortex light is of a topological nature and is therefore extremely

¹ Published in *Science*, 2016, n. 353, pp. 464-467.

robust. Like the frequency of light, twisted light beams can be used to encode the information to be sent on optical fiber. The possibility of encoding information (bits) in the swirling motion of light, as well as in its color, allows for a significant increase in the amount of information transmitted at each individual frequency. Therefore, it is expected to revolutionize optical communication systems in the near future, with foreseeable outstanding impacts both on the economy and on society. The need for ever faster and higher information flows is in fact essential to sustain the so-called fourth industrial revolution and to strengthen growing connections among physical, digital and biological worlds.

As demonstrated in this research project, the ability to generate twisted light directly from a very small laser device, with semiconductor technology that is compatible with current optical communication systems, represents a fundamental result for the development of the next generation of optical communication systems with a very high bit rate. The laser manufactured by the US-Italy team is a small ring of optically-pumped semiconductor material on which particular corrugations are made. Along the ring, light can propagate in both directions – clockwise and counterclockwise – so that the light extracted from the device is generally free of vorticity. The main idea of the work is to exploit the properties of the quantum exceptional points, which are special mathematical singularities created here by means of suitable metallizations along the ring. At a quantum exceptional point, circulation of light occurs stably in one direction only. The light extracted from the ring, by means of a second corrugation (optical grating), shows a vorticity (topological charge) that can be suitably varied and used to encode information.

THE AWARD

The *Aspen Institute Italia Award* for scientific research and collaboration between Italy and the United States was launched in December 2015 in keeping with the Institute's commitment to encouraging and developing international leadership and transatlantic relations. Every year, the prize will be awarded to a research project studying applied or theoretical natural sciences, in which scientists and/or organizations from Italy and the US collaborate.

The Prize consolidates the Institute's commitment towards initiatives and meetings on important topics in the fields of science and technological innovation, with particular reference to their relevance to Italy.

The members of the Award committee for the 2020 Award are:

- Professor Giulio Tremonti, Chairman of the Award committee; Chairman, Aspen Institute Italia, Rome
- Professor Domenico Giardini, Chair of Seismology and Geodynamics, ETH, Zurich
- Professor Luciano Maiani, Professor Emeritus of Theoretical Physics, "La Sapienza" University, Rome
- Professor Gaetano Manfredi, Full Professor of Construction Design, University of Naples Federico II; Minister of University and Research
- Professor Giovanni Rezza, Director, Department of Infectious Diseases, Istituto Superiore di Sanità, Rome
- Mr. Lucio Stanca, Vice Chairman, Aspen Institute Italia, Rome

The winners of the 2016-2019 editions of the *Aspen Institute Italia Award* were:

2016: *Spatiotemporal spread of the 2014 outbreak of Ebola virus disease in Liberia* which created a mathematical model to interpret the spread of Ebola.

2017: *Wind from the black hole accretion disk driving a molecular outflow in an active galaxy* that demonstrates that wind coming from black holes contributes to the formation of new stars inside different galaxies.

2018: *The quest for forbidden crystals* that demonstrates the ample scope for discovering new quasicrystals in nature (with chemical compositions as-yet unexplored in the laboratory) and for extending the results of this new field of research to other scientific spheres and to groundbreaking industrial applications.

2019: *A Test for Creutzfeldt–Jakob Disease Using Nasal Brushings* that represents a significant step forward in diagnosing prion diseases; above all, however, it opens a new and broad perspective of diagnosis in the field of those neurodegenerative diseases that are more common and that have a significant social and economic impact.