Editorial: Collection in honor of E. I. Rashba and his fundamental contributions to solid-state physics

In October 2022, Professor Emmanuel Rashba marked his 95th birthday. He has been a witness and a major contributor to the scientific revolution that has been changing the world over the last 100 years. During this time solid state physics has come to the forefront of modern science and has led to the development of modern technology. Rashba's impact on solid state physics is hard to overestimate, in terms of both breadth and depth. His results underlie several areas of research that are conducted around the globe. They have engaged several generations of scientists and have led to numerous applications. Beginning in the present issue, and continuing over the next few months, Physical Review B will be publishing a collection of papers dedicated to Rashba, presenting work that grew out of his ideas.

Emmanuel Rashba was born in Kyiv in 1927. He graduated from Kyiv University in 1949, received a Ph.D. in 1956, and a higher doctorate (the USSR Doctor of Science) in 1963. He worked in the Kyiv Institute of Physics and then the Institute of Semiconductors from 1954 until 1966, when he moved to the Landau Institute. In 1991 he moved to the US, first to the University of Utah. From 2004 until 2015 he worked at Harvard University. He received numerous international awards and honors, culminating in the Buckley Prize of the American Physical Society.

Rashba's name is attached to several effects. The most frequently cited are those related to the spin-orbit coupling in solids. This coupling was described by Rashba very generally using symmetry-based arguments [1–3]. It can lead to momentum-dependent splitting of spin bands and to displacement of band extrema into a loop in momentum space, in certain bulk crystals. In two-dimensional systems on semiconductor surfaces a major factor behind the Rashba spin effects is the broken symmetry in the direction normal to the layer [4]. Besides the changes in dispersion laws, an important consequence of the spin-orbit coupling is the possibility of electric-dipole spin resonance, where resonant absorption at a spin-transition frequency has an oscillator strength determined by the electric dipole moment. Along with this comes the possibility of combined resonance at frequencies that are linear combinations of the frequencies of orbital and spin motion, an effect that can also come from an inhomogeneous magnetic field [5]. Spin-related Rashba effects have found a multitude of applications. Critically important for many of them is the possibility to control electron spin by an electric field. Rashba's spin-orbit coupling underlies much of the modern spintronics.

Another large group of Rashba effects concerns excitons. Rashba showed that, counterintuitively, free and self-localized states of excitons coupled to phonons can coexist [6–8]. Excitons can make transitions between the states via tunneling or activation. Rashba also discovered that excitons coupled to impurities can lead to strong absorption lines in the spectra of molecular crystals and semiconductors. This giant oscillator strength effect is a consequence of a large size of the shallow impurity-bound excitons [9]. The effect extends to excitons in quantum dots and quantum wells, leading to sub-nanosecond radiative decay time. The Rashba theory of excitonic effects has explained numerous observations and has led to qualitative and quantitative predictions that have been and are being tested in numerous laboratories around the world.

Rashba has initiated the study of a large group of anisotropic size effects in multi-valley semiconductors and semimetals [10,11]. These effects result from the separation of the carriers into groups between which the relaxation is relatively slow. Transport coefficients in such groups are often anisotropic, as in the case of transport in an individual valley in a cubic crystal. Once the diffusion length associated with a

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long relaxation time becomes comparable to the size of the system, the passage of a current produces nonequilibrium carrier distributions, strongly changing the transport compared to large systems. The studies of these effects have led to a number of applications, with valleytronics being an outgrowth.

Following his move to the United States in 1991, Rashba remained very active, contributing advances in subjects including spin injection, the manipulation of electron spins by electric fields, spin-Hall effects in semiconductors, the theory of chiral Fermi liquids, and spin-dynamics in GaAs quantum dots and carbon nanotubes, with potential applications in spintronics or quantum computation. He was the author, or coauthor, of more than fifty papers between 1991 and 2019.

The six papers dedicated to Emmanuel Rashba that are included in the current issue of Physical Review B demonstrate the far reaching impact of his ideas and results. More is to come. As guest editors, we thank the contributors to this collection, as well as Yonko Millev from Physical Review B, for their support of this project.

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