Pierre Sikivie - Biosketch

Pierre Sikivie is a Distinguished Professor of Physics at the University of Florida in Gainesville. He is best known for devising methods to detect axions and for investigating their cosmological properties.

He was born in Belgium in 1949 and attended the University of Liège, obaining the degree of "Licencié en Sciences Physiques" in 1970. His next five years were spent in New Haven, CT, attending Yale University as a physics graduate student. His PhD advisor was Prof. Feza Gürsey. With Gürsey and Ramond, he proposed a grand unified theory based on the exceptional Lie group E6. He held postdoctoral research positions at the University of Maryland, the Stanford Linear Accelerator Laboratory, and CERN, working on diverse topics in grand unification, CP violation, classical Yang-Mills theory and dynamical symmetry breaking ("technicolor"). He was married to Cynthia Chennault in 1980. Both obtained faculty positions at the University of Florida in 1981. They have two children.

Axions were proposed in the late seventies as a solution to the Strong CP Problem, the puzzle why the strong interactions conserve the discrete symmetries P and CP in the face of the breaking of these symmetries by the weak interactions. It was thought in the early eighties that the Strong CP Problem could be solved by an axion which is so weakly coupled, the so-called "invisible" axion, as to be free of observable consequences. In 1982, Sikivie showed that all axion models have domain walls and that these have disastrous cosmological consequences unless certain conditions are met. This work showed that "invisible" axions have observable consequences after all. It also opened up the rich research area of axion cosmology. In 1983 L.F. Abbott and Sikivie showed that axions are copiously produced during the QCD phase transition in the early universe. Axions are over-produced in the simplest scenarios if their mass is less than a few micro-eV. Similar results were published at the time by J. Preskill, F. Wilczek and M. Wise, and by M. Dine and W. Fischler. Axions with mass of order a few micro-eV became a dark matter candidate as a result of these works. Sikivie and his colleague astrophysicist Jim Ipser showed that, in spite of their very small mass, axions produced during the QCD phase transition are a form of cold dark matter, with properties very different from neutrinos, one of the leading dark matter candidates at the time.

In 1983, Sikivie showed that dark matter axions are detectable on Earth by converting them to microwave photons in a cavity permeated by a strong magnetic field, the axion haloscope. He also showed that axions emitted by the Sun are detectable on Earth by converting them to x-rays in a laboratory magnetic field, the axion helioscope. Axion to photon conversion in a magnetic field, which may justifiably be called the "Sikivie process", has been used in a wide variety of contexts. Axion haloscope experiments were carried out at Brookhaven National Laboratory, the University of Florida, Kyoto University, Lawrence Livermore National Laboratory, the University of Washington, and Yale University. Several new haloscope experiments are being planned in Korea and Australia. Axion helioscope experiments were carried out at Brookhaven National Laboratory, the University of Tokyo, and CERN. A new large experiment (IAXO) is being proposed. "Shining light through walls" experiments in which the Sikivie process and its inverse are used to convert photons to axions on one side of a wall and convert the axions back to photons on the other side were carried out at Brookhaven National Laboratory, Jefferson National Laboratory, Fermilab, in Toulouse (France), at DESY (Germany) and at CERN. A very large experiment called ALPs II, using recommissioned HERA magnets, is presently under construction at DESY. The Sikivie process in astrophysical magnetic fields is being investigated as an explanation for certain astronomical observations, such as the unexpected transparency of the universe to high energy gamma rays.

Sikivie and collaborators developed the study of caustics as a tool to investigate the properties of dark matter. They showed that the fall of cold collisionless dark matter in and out of a galactic halo necessarily produces inner as well as outer caustics in the halo. The inner caustics are rings with a distinct tricusp cross-section, described by the elliptic umbilic catastrophe, in case the dark matter falls in with net overall rotation. Sikivie and collaborators found observational evidence for the existence of such caustic rings in galactic disks. This raised a puzzle because ordinary cold dark matter does not fall in with net overall rotation. It can be shown instead to fall in with an irrotational velocity field. The puzzle was solved in 2009 when Q. Yang and Sikivie showed that dark matter axions form a Bose-Einstein condensate. The axions rethermalize by gravitational self-interactions while falling into galactic halos and as a result go to the lowest energy state available to them, which is a state of net overall rotation. Sikivie showed that the rethermalizing axion Bose-Einstein condensate explains in detail and in all respects the evidence for caustic rings of dark matter.

Sikivie has been the recipient of several honors, including Fellowship in the American Physical Society since 1994, the Jesse W. Beams Medal of the Southeastern Section of the APS in 1996, a Guggenheim Fellowship in 1998, and an IBM Einstein Endowed Fellowship at the Institute for Advanced Study in Fall 2005.