Physicists generate ball-lightning in the lab

A ball-lightning-like plasma cloud is produced in an underwater discharge. (Photo: D. Lange, IPP)

Scientists in the joint study group of Max-Planck-Institut für Plasmaphysik and Berlin's Humboldt University have generated ball-lightning in the laboratory - or, to be more precise, ball-lightning-like plasma clouds. The physicists produce luminous plasma balls above a water surface which have lifetimes of almost half a second and diameters of 10 to 20 centimetres.

Ball-lightning is described as a luminous phenomenon occurring during thunderstorms. It is a mystery, however, that they should be visible not as a brief flash, i.e. just for microseconds, but exist for several seconds, i.e. a hundred thousand times as long as a flash of lightning. Besides such famous figures as the Roman philosopher Seneca, Pliny the Elder, Charlemagne and Henry II of England, in modern times the Nobel Prize winners in physics, Niels Bohr and Pjotr Kapitza, claim to have observed this phenomenon.

Less renowned observers also report unexpected encounters with ball-lightning; the internet features more than a million entries on the subject. On the other hand, the phenomenon is so rare that there are still no reliable data available. Accordingly, doubtful attempts at interpretation are rampant, ranging from black holes to mini nuclear explosions and esoteric explanations.

"In view of this incertitude it has been variously attempted to induce the phenomenon under controlled conditions in the laboratory", states Prof. Gerd Fussmann, head of the plasma physics study group of IPP and HUB in Berlin. One research group already succeeded in producing plasmoids fed with microwaves - luminous plasma balls consisting of an ionised gas - which it would be fair to class as ball-lightning. A similar effect is caused by electric sparks conducted over organic materials. About four years ago a study group in St. Petersburg successfully used electric discharges above water surfaces to produce spherical luminous formations that come appreciably closer to the natural phenomenon. For it is probable that flashes of lightning and water must be interacting when ball-lightning occurs.

Stimulated by the Russian experiments, the plasma physics study group in Berlin is conducting investigations in which plasmoids are produced above a water surface that have lifetimes of about 0.3 second and diameters of 10 to 20 centimetres. This involves igniting a short high-voltage discharge in a water tank; when it decays a plasma ball then emerges from the surface.

Apart from the powerful capacitor bank needed to supply energy, the experimental setup is rather simple: A glass beaker filled with salt water contains two protruding electrodes, one of which being insulated from the surrounding water by a clay tube. When a high voltage is applied, a current of up to 60 amperes flows through the water for 0.15 second. Flashover from the water enables the current to enter the clay tube, where it causes the water contained there to evaporate. After the current pulse a luminous plasmoid consisting of ionised water molecules appears.

The facility can generate impressive "ball-lightning" in every possible manifestation and colour about every five minutes. Professor Fussmann: "Why luminous phenomena occur at all is anything but clear: They continue to be visible about 300 milliseconds after the current has decayed and the energy input is thus cut off; however, they should really be quenched after a few milliseconds at most. Furthermore, the plasma glows very brightly, although the plasmoids appear to be rather cold. A sheet of paper placed above them does get lifted, but it does not catch fire."

These puzzling physical phenomena are now to be clarified in several diploma theses. This calls for systematic analysis of the processes involved - for example, by spectroscopic methods - and comparison with the existing theoretical formulations. "Although "ball-lightning" does not directly fit into the research field of IPP, viz. investigation of extremely hot plasmas such as are needed for a fusion power plant", states Prof. Fussmann, "it is also an attractive plasma physics topic with which students can acquire knowledge of sophisticated measuring technique and theory from an interesting natural phenomenon."

Source: Max-Planck-Institut