When vacuum is hot

Brazilian researchers propose an experiment to determine whether empty space can heat an accelerated object

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Calculations performed by a group of theoretical physicists in São Paulo indicate that conducting an experiment that uses the current generation of particle accelerators could prove the existence of what is known as the Unruh effect, which was proposed more than 40 years ago. This phenomenon is characterized by radiation that is composed of elementary particles that can only be recorded by a body that is undergoing extreme acceleration. If the effect really exists, then empty space must be hotter for a hypothetical observer undergoing accelerated movement than for a traveler moving at a constant velocity. In the latter case, the temperature of the vacuum is absolute zero. According to the calculations of the team composed of physicist George Matsas and his PhD student Gabriel Cozzella of São Paulo State University (Unesp) and physicists André Landulfo of the Federal University of the ABC (UFABC) and Daniel Vanzella of University of São Paulo (USP), the heat generated by the Unruh effect could be seen as radiation emitted by electrons accelerated in a laboratory.

The team's work suggests that the Unruh effect could be observed when a cloud of electrons emitted by a particle accelerator is rapidly decelerated inside a tube due to the presence of strong electric and magnetic fields. Both force fields would oppose the direction in which the cloud is moving. This situation would cause the electrons to decelerate and follow a spiral trajectory while emitting light at various frequencies. They believe the effect is encoded in the radiation emitted by these electrons, as a type of signature. "If the Unruh effect does not exist, there will be an impact on the radiation emitted by electrons for lower frequencies, challenging the "sacred" predictions of classical 19th century electrodynamics," says Matsas who, together with Cozzella, Landulfo and Vanzella, wrote a scientific article published on April 21, 2017 in *Physical Review Letters*, in which they defend the feasibility of the experiment. The proposal is contrary to the beliefs of some physicists who are skeptical with respect to the possibility of confirming the effect experimentally using instruments that employ current technology.

If the idea is shown to be feasible, then the existence of the hypothetical phenomenon could be proven in Brazil, in theory. "I am still not convinced of the feasibility of the experiment," says experimental physicist Marcos Martins, coordinator of the microtron linear electron accelerator laboratory at USP, with whom the theoretical group is discussing the possibility of testing for the phenomenon. "The Unruh effect would appear in the radiation of the electrons in the MHz frequency, in the same band as signals emitted by radio and TV stations, but at a very low intensity, which could make it impossible to detect."

AVALANCHE OF PARTICLES

The existence of the effect was proposed in 1976 by theoretical physicist William Unruh of the University of British Columbia in Canada. Unruh imagined an elementary particle detector moving with great acceleration. Traveling along a straight line in completely empty space, one would expect that the highly accelerated particle detector would record the same number of particles that it would record if it were not moving: zero. The Canadian's calculations, however, showed that the accelerated detector would record an avalanche of elementary particles appearing in space out of nothing. The greater the acceleration of the detector, the hotter the pool of particles in which the detector would be immersed. The effect discovered by Unruh completed previous studies by U.S. mathematician Stephen Fulling and clarified the results

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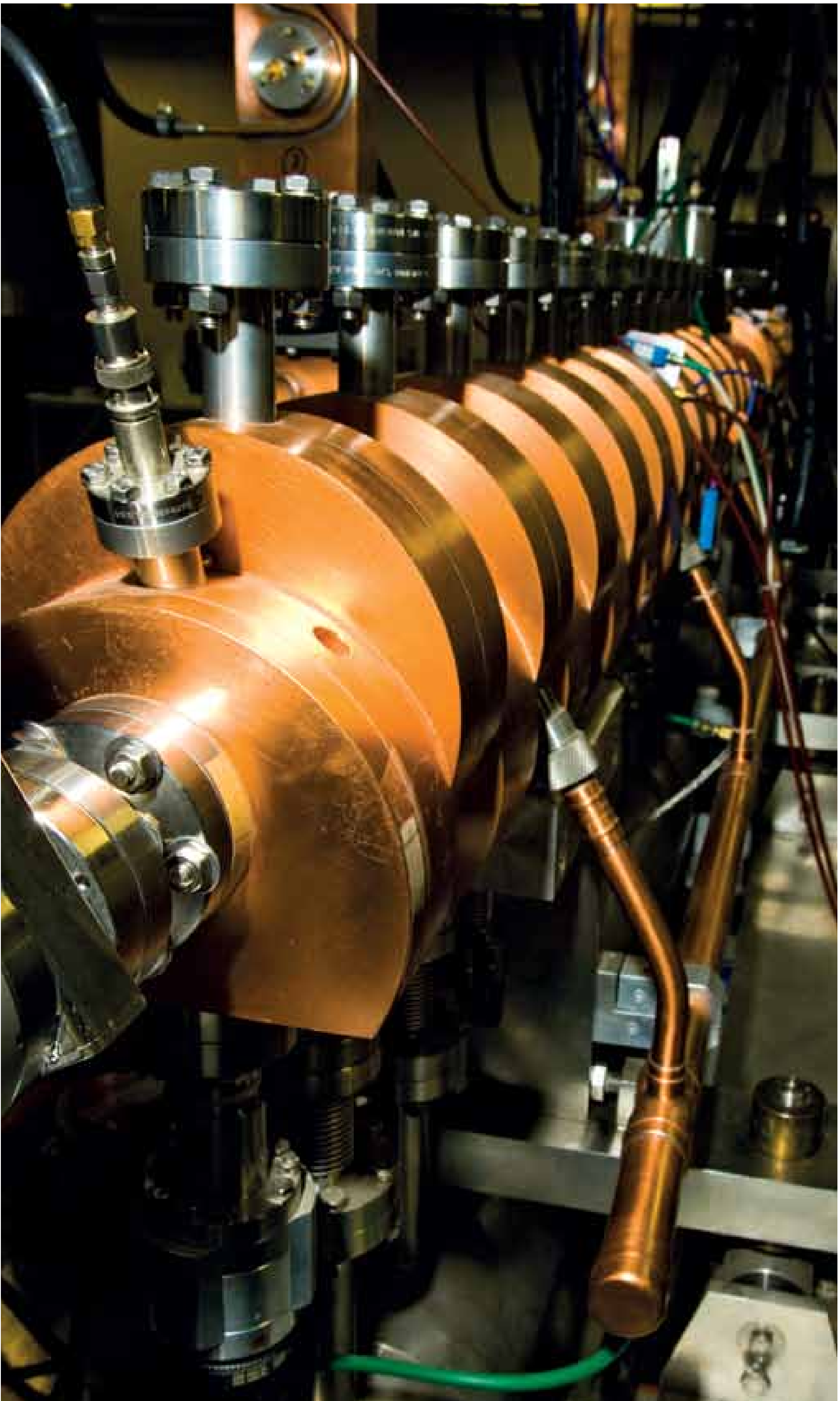
obtained independently during the same period by Australian Paul Davies.

The conclusion of Fulling, Davies and Unruh was a direct consequence of one of the best-tested hypotheses in physics, quantum field theory, which is the basis of the standard model, the set of mathematical formulas and rules that describe the behavior of all known elementary particles. The basis of quantum field theory, proposed by different physicists from the 1920s–1940s, combines the principles of Einstein's specific theory of relativity and quantum mechanics.

Most physicists who investigate the consequences of the Unruh effect are convinced that the phenomenon must exist if quantum field theory is completely correct. One of the results that demonstrate this necessity was obtained by Matsas and Vanzella in 2001. These two investigators confirmed that the lifetime of a proton subject to extreme acceleration could only be calculated correctly when the Unruh effect is accounted for (*see* Pesquisa FAPESP *Issue No. 69*). However, not everyone is convinced. Some theoreticians, such as Vladimir Belinski at the International Center for Relativistic Astrophysics in Italy, argue that there is a mathematical error in the deduction of the effect, a complaint addressed by Unruh and others. "We hope that the experiment convinces the skeptics regarding the coherence of the Unruh effect," said Fulling to the journal *Science* when commenting on the proposal by the physicists from São Paulo.

Both sides of the debate agree that the radiation predicted by the Unruh effect has not been observed because it is normally too weak. "To effectively create a pool of elementary particles at a temperature of 1 Kelvin (-272°C), one would have to build a probe capable of withstanding acceleration billions and billions of times greater than that withstood by current rockets," comments Cozzella, first author of the article. ■



The microtron linear electron accelerator at USP is one of the devices in which, in theory, the Unruh effect could be observed

Project

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COZZELLA, G. *et al.* Proposal for observing the Unruh effect using classical electrodynamics. **Physical Review Letters**. v. 118. 21 April. 2017.