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Counting individual ions by tagging them with nanoparticles

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Interaction of high-energy particles with molecules in gases generates ions. Measurements of ultra-low concentrations of ions in gases are of fundamental and practical importance for science and technology, for example, for cosmic ray and high-energy particle physics, the detection of explosives in airports or biomarkers in medical diagnostics. The Wilson cloud chamber is employed in high-energy physics. Geiger counters, scintillation detectors also have been widely used for detecting ionising radiation. Often the Faraday cup is employed to transfer ion concentrations in an electric current that is then amplified and measured. The Faraday cup devices detection limit (circa 10^3 ions per second) is determined by thermal fluctuations of the electron gas in metals that causes a high background noise. One of the main challenges is to increase the sensitivity of ion detection. A novel concept has been invented and devices have been developed that enables detection of individual ions in gases by tagging them with neutral nano-objects. The concentration of ionized molecules was measured and a detection limit of 5 cm^3 was observed. A novel method of counting ionized molecules in gases allows detection of individual ionized molecules by means of tagging them with readily detectable nanoparticles. The method was shown to be able to detect 1 ion in 10^4 cm^3 of air in an underground laboratory where the cosmic ray level is negligible. This is an extremely low electric current down to zeptoampere level (1 zA = 10^{-21} A). This method opens doors for advances in detection sensitivity in chemistry, biology, medicine and physics. One such application is detection of high-energy cosmic ray particles with energy above 10^{16} eV. The cosmic ray flux for these energies is below 1 m^{-2} yr^{-1}. It is a challenge to detect these particles with conventional means. However, there are no physical limitations to build an ion tagging detector with the sensor area much greater than 1 m^2, e.g. up to 10^4 m^2 or even greater. This may help in finding the maximal energy of cosmic ray particles: The Greisen–Zatsepin– Kuzmin limit. The new method also could not be applied for detection of weakly interacting massive particles in environments where cosmic rays are not present such as deep underground mine laboratories.

Biography

Boris Gorbunov MSc, DSc, PhD is Technical Director of ANCON Technologies Limited and Technical Director of Ancon Medical Inc. His qualifications include BSc, MSc Molecular Physics – Novosibirsk State University (Russia), PhD Physical Chemistry – Novosibirsk State University (Russia), DSci Chemical Physics – Moscow Karpow Institute (Moscow)

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