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Progress on Optical Stochastic Cooling in IOTA

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The world's first experimental observation and achievement of 'optical stochastic cooling'(i.e., relativistic charged particles cooled via feedback from their own optical radiation) in the IOTA storage ring at Fermilab, USA was reported in Nature, August 11, 2022. Recapturing that achievement, I will report on further progress in optical stochastic cooling in IOTA to date. The method has direct applications towards cooling of exotic unstable particles like muons and towards fundamental studies of "quantum optics and entanglement" of 'electric charge'and 'virtual quanta'in an otherwise benign electron-photon Feynman vertex.

Historical Prelude: The technique of "Stochastic Cooling"of phase space of a particle beam, using microwave techniques in the GHz frequency range, has been employed historically in particle colliders, leading to groundbreaking discoveries. 'Cooling'increases the probability of interactions in colliding beams, thus enhancing the likelihood of observing rare physics events. The first important advance in this area was stochastic cooling of anti-matter (e. g. 'antiprotons'), invented by Simon van der Meer (Nobel Prize, 1984), which was instrumental in the discovery of the W and Z Bosons at CERN in 1983 and the 'top'quark at Fermilab years later. Stochastic Cooling reduces the random motion of the beam particles through repeated granular sampling and correction of the beam's phase-space structure, thus resembling a 'Maxwells demon'. The extension of Stochastic Cooling from the microwave regime up to optical frequencies and bandwidths, samples and exploits a charged particle' s radiation to affect its own phase space with a resolution of 'microns', leading to increases in the achievable cooling rates by three to four orders of magnitude.

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