## Casimir Momentum of Chiral Molecules and Nucleons in Magnetic Fields

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The break of symmetries in quantum systems gives rise to a number of phenomena which allow to probe the topology and symmetry properties of the underlying field theories and vacuum states. Examples of these phenomena are the formation of magnetic vortices in the spontaneous breaking of the U(1) electromagnetic symmetry of superconductors, or the asymmetric emission of electrons in the beta decay of polarized neutrons due to Parity violation in the electroweak theory. On the other hand, translation invariance of space-time implies total momentum conservation. Dynamically, it reflects on the newtonian action-reaction principle. The latter implies that, in order for a given system to acquire a net momentum, it has to interact with an auxiliary system which gains an equivalent momentum in the opposite direction. Generally, the greater the inertia of the auxiliary system, the more efficient the transfer of momentum to the system of interest is. In particular, since the quantum vacuum contains an infinite number of energy carriers, i.e., virtual particles, its inertia is huge. As a result, if we consider a material object as our system of interest, and the quantum vacuum as the auxiliary system, it is possible to transfer momentum from one another in an efficient manner, provided that Parity (P) and Time-reversal (T) symmetries are broken [1, 2].

In this talk I will explain first how the break of P and T symmetries on the ground state of a chiral molecule in an external magnetic field yields a net kinetic momentum on the molecule, with null back-reaction on the source of magnetic field [3, 4]. In accordance with total momentum conservation, a net momentum of equal strength and opposite sign is transferred to the virtual photons of the electromagnetic vacuum, which is referred to as *Casimir momentum* [1,3]. The experimental confirmation of this phenomenon is an ongoing issue.

In the second part of my talk I will show how nucleons can be accelerated by a uniform external magnetic field. In this case, Parity is naturally broken by the electroweak Hamiltonian, and it is the virtual leptons – i.e., electrons (positrons) and (anti) neutrinos-- that carry the excess of momentum. Interestingly, this phenomenon is accompanied by the polarization of the electroweak vacuum. From a phenomenological perspective, it may have an impact on the dynamics of neutron stars, where extremely high magnetic fields are naturally present.

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