The break of symmetries in quantum systems gives rise to a number phenomena which allow to probe the topological and symmetry properties of the states of the systems, as well as of their underlying field theory. In particular, the break of Parity (P) and Time-reversal (T) symmetries in atomic systems engenders a net force on the systems. This force is accompanied by the transfer of momentum to the vacuum fluctuations of the fields which mediate the internal interactions of the systems.

For instance, a net force has been found on an atomic system made of two dissimilar atoms, one of which is excited [1]. In that case, the atomic system is in a state of non well-defined parity, and the virtual photons which mediate the dipole-dipole interaction participate in the non-reversal de-excitation process. The Hamiltonian of the electromagnetic interaction is, however, P&T invariant.

On the other hand, in the beta decay of a polarized neutron, the neutron acquires a net momentum along the spin axis prior to its decay into a proton, while an opposite momentum is transferred to the virtual electrons and antineutrinos which mediate the weak nuclear self-interaction [2]. Nonetheless, in contrast to the electromagnetic interaction, it is the Hamiltonian of the weak nuclear interaction that violates the mirror symmetry, and not the neutron state.

In this talk I concentrate on the kinetic momentum acquired by a chiral molecule along a uniform magnetic field. We use Condon's model [3] to describe the chiral molecule. In this model, an only anisotropic oscillator determines the optical activity of the molecule. An effective harmonic potential for the chromophoric electron is perturbed by its Coulomb interaction with the neighboring atomic groups, breaking this way the mirror symmetry. In addition, a strong external magnetic field breaks time-reversal. Under these conditions, it is symmetry-allowed for the molecule to acquire a kinetic momentum. This momentum is proportional to the fine structure constant and to the rotatory power of the molecule. Correspondingly, 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' [4,5]. The Casimir momentum has its origin in the non-reciprocity of the spectrum of vacuum photons. Our quantum approach reveals that this is caused by the Doppler shift of the photons' frequency due to the net momentum of the chromophoric electron parallel to the magnetic field. The kinetic energy of the molecule is found to be part of the magnetic energy associated with the quantum corrections of the molecular magnetization [6]. The experimental confirmation of this phenomenon is an ongoing issue.