Quantum spintronic phenomena

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In some physical systems, the inherent coupling between spatial and magnetic degrees of freedom – the spin-orbit interaction – gives rise to a variety of interesting possibilities/phenomena: (i) the 'spin field-effect transistors' [1] the Spin Hall effect and the relativistic Zitterbewegung [2], (iii) novel Bose-Einstein condensates with synthetic gauge potentials [3] (iv) new 'states of matter' or topological insulators [4], and (v) Majorana modes in unconventional superconductors coupled to quantum wires [5]. The fascinating subjects in (iii)-(v) have warranted a renewed interest in the spin-orbit interaction. In this talk I will review the basics of the spin-orbit interaction and overview the topics in (i)-(v) with emphasis on those in (iii)-(v). I will also discuss some current topics of research in my group, e.g., helical edges states in multiple topological mass domains [6], (pseudo) spin-orbit coupling in 'cross-dressed' atoms [7] (analogies between trapped bosonic condensates and spin-polarized fermionic quantum liquids [8] will possibly be addressed) and Rashba-Dresselhaus coupled two-dimensional electron gases [9] with two subbands [2], in which crossed persistent helices can appear [10]. I acknowledge support from FAPESP and CNPq.

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