Condensed matter and statistical physics

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Electrical properties of sensing proteins [1–3].
Sensing proteins (receptors) are nano-structures of about 5 nm diameter that exhibit very complex behaviors (they can pump ions, use energy from the environment, change their conformation, catalyze some reactions, etc). They are constituted by a specific sequence of amino acids (primary structure) and in this sequence the space organization (tertiary structure) is codified. The functioning of these macromolecules is intrinsically connected with their tertiary structure, which modifications are normally associated with their biological function. With the advance of nanotechnology, the investigation of the electrical properties of receptors has emerged as a demanding issue. Beside the fundamental interest, the possibility to exploit the electrical properties for the development of bio-electronic devices of new generations has attracted major interest of many researchers. From the experimental side we cite three complementary kinds of measurements: (i) current voltage (I-V) measurements in nanometric layers of a given protein sandwiched between macroscopic contacts, (ii) I-V measurements within an AFM environment in nanometric monolayers of a given protein deposited on a conducting substrate, (iii) electrochemical impedance spectroscopy (EIS) measurements on appropriate monolayers of self-assembled samples of a given protein. From a theoretical side, a microscopic interpretation of these experiments is still a challenging issue. These papers present recent theoretical results carried out within the European project BOND (Bioelectronic Olfactory Neuron Device), which provides a first quantitative interpretation of charge transport experiments exploiting static and dynamic electrical properties of several sensing proteins. To this purpose we have developed an impedance network protein analogue (INPA), which

Maximum entropy principle for quantum exclusion statistics [4].
Using the Wigner representation, compatibly with the uncertainty principle, we formulate a quantum maximum entropy principle for the fractional exclusion statistics. By considering anyonic systems satisfying fractional exclusion statistic, all the results available in the literature are generalized in terms of both the kind of statistics and a nonlocal description for exclusion gases. Gradient quantum corrections are explicitly given at different levels of degeneracy and classical results are recovered when $\hbar$ tends to 0.

Electrical noise in physical systems and multibarrier diodes [5,6].
Noise spectroscopy in physical systems has been reviewed by using the light color analogy. Furthermore, shot noise suppression in resonant diodes with transport controlled by coherent tunneling is investigated using the tunneling transparency $D(\epsilon)$ obtained from an exact numerical solution of the Schrödinger equation in the presence of an applied voltage. The cases of three potential barriers in GaAs/AlAs heterostructures is considered. Results show that the use of an exact dependence of $D(\epsilon)$ confirms the existence of a voltage range of values where the Fano factor γ is significantly less than 0.5, in agreement with previous findings obtained within a Lorentzian approximation and with experiments available in the literature for different heterostructures. At increasing values of the barriers width the Fano factor recovers the 0.5 value common to a transport controlled by the sequential tunneling regime.

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