Ionic Coulomb blockade and selectivity in biological ion channels

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Biological ion channels are essential to life in all its forms. By enabling the selective transfer of ions across lipid bilayers, they facilitate the establishment of intracellular media compatible with the biochemical reactions essential for replication and metabolism. Their selectivity is known to be associated with fixed negative charge Q_f in a narrow part of the channel called the selectivity filter. Remarkably, many properties of ion channels can now be understood [1] by analogy with the physics of quantum dots: e.g. Coulomb blockade oscillations in quantum dots correspond to the alternating conduction bands and stop bands seen for ions in channels as Q_f is varied (emergent phenomena, quite unexpected from known channel structure). The first systematic experimental and numerical tests of the ionic Coulomb blockade picture [2] will be discussed together with recent work developing a fundamental statistical theory [3] of the conduction process.

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