Beauty and the Quantum

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I will present a new mechanism, called "***quantum self-organization***", to enhance the collective modes in quantum many-body systems. The collective modes appear often with beautiful patterns, leading to the above title.

Let me explain this by taking an example. The naïve picture of the shape of atomic nuclei is a sphere, but many nuclei are deformed to ellipsoids. This deformation is due to the quadrupole component of nuclear forces, which makes the quadrupole moment larger. We recently found that the actual deformation is determined not only by the effect of this quadrupole interaction but also by the balance with the resistance power against the deformation. Historically, the pairing interaction, like the BCS theory for superconductivity, was known to contribute to the resistance. We found that the single-particle energies are another major resistance power. The bound quantum system is characterized by discrete single-particle energies, and if they are split strongly, the deformation is suppressed. This is common in collective motions based on the Jahn-Teller effect. We found that the nuclear force, particularly its monopole component, can organize single-particle energies so as to be more favorable for a given collective mode, by distributing protons and neutrons over various orbits in an optimum way. This mechanism is called ***quantum self-organization***. In short, once the nucleus "decides" to have an ellipsoidal shape, the nucleus self-organizes its single-particle quantum structure in a favorable way. This is somewhat analogous to biological evolution, and can be a general feature in many-body quantum systems. On the other hand, "many-body" is a crucial key word here. I will present concrete examples, and may suggest possible cases other than atomic nuclei, if possible. In nuclear physics, the quantum self-organization helps the creation of beautiful rotational bands, as well as intriguing phenomena like quantum phase transition, *etc*.