Do classical laws arise from quantum laws?

“The physics community is mostly divided into two groups,” Johannes Kofler tells *PhysOrg.com*. “One group believes that quantum theory is underlying the classical world, and that classical physics comes from the quantum. The other group thinks that quantum physics has to be altered. It forbids that quantum mechanics works on a macro level in the classical world by postulating additional laws.”

Kofler belongs to the former group. He and Časlav Brukner, both from the University of Vienna and from the Institute for Quantum Optics and Quantum Information (IQOQI) of the Austrian Academy of Sciences, have developed a novel theoretical approach to understanding the transition from quantum to classical physics.

Their work has been published in *Physical Review Letters* with the title, “Classical World Arising out of Quantum Physics under the Restriction of Coarse-Grained Measurements.”

“Our motivation is to understand how the classical world comes out of quantum physics,” Kofler says. “The established approach in research is decoherence where one has to take into account the complexity of systems and interactions with environment.” It is interaction with the environment that brings decoherence into play, destroying quantum coherences and making it impossible to observe quantum phenomena. “We believe we found a process complementary to decoherence which can explain the quantum-to-classical transition.”

Instead of referring to the environment of a system, or even to the change quantum laws, Kofler and Brukner created a theoretical framework that stresses the use of measurement apparatuses. It is their restricted accuracy which limits the observability of quantum phenomena.

“We took a rotating spin as a model system,” Kofler expounds via email. “There is a condition which all classical theories have to obey, called the Leggett-Garg inequality, but which can be violated by quantum mechanics.”

Kofler and Brukner demonstrated that the time evolution of a quantum system, no matter how macroscopic the system is, cannot be treated in a classical sense. “Just because something is big doesn’t mean it can be described by classical physics.” Then referring back to the case of spin, he continues: “Arbitrarily large spins can still have a quantum time evolution and violate the Leggett-Garg inequality.”

Next, the two realized that coarse-grained measurements are used in realistic conditions, such as situations that we are confronted with every day, as the resolution of the apparatuses usually is limited. “If you are bound to restrict yourself to coarse-grained measurements of the spin,” Kofler explains, “you get the classical Newtonian laws of motion.”

“Start with a spin system of macroscopic size and the Schrödinger equation that produces the quantum time evolution. Restrict the precision of your measurements and you can see the Newtonian physics emerging.” Kofler explains that measurements in quantum mechanics generally change the system. “But under our coarse measurements this change is such that a classical description is possible.”

Kofler admits that so far this work is not fully finished. “It’s really fair to say that classical physics out of quantum theory has not been entirely achieved yet by anybody,” he says.

But he and Brukner remain optimistic that at some point we will be able to get a *complete* understanding of how our well-behaved classical world emerges from the strangeness of quantum physics.