Observation of a non-EPR nonlocality based on fundamental indivisibility of macroscopic quantum states

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We have observed a new type of nonlocality which is unrelated to the quantum entanglement but is due to what Bell mentioned as an implicit nonlocality of a wavefunction. In essence, this nonlocality is related to fundamental indivisibility of a quantum state regardless of its spreading over the real space. This type of nonlocality has never been taken seriously simply because it requires an individual macroscopic-scale quantum state (MQS) that seems unavailable at least for a real experiment. An opportunity arose only recently with the discovering of a macroscopic quantum phase with a number of spatially-separated orbit-like electronic MQSs. The phase emerges through a breaking-symmetry quantum phase transition from the Quantum Hall state of matter so that the MQSs are very similar to those responsible for the integer Quantum Hall effect. In the experiment, by means of laser light we excite electrons into the orbit-like MQSs within a local spatial domain crossed by the orbits. But according to the principles of quantum mechanics, the excited electrons immediately become available for a local scattering in any other spatial domains crossed by the orbits regardless of their remoteness from the excited domain. So if local scattering does happen, then we face spatially-discontinuous electron transitions with the lengthscale of MQSs and as the scattering time is generally insensitive to the MQS length, the ratio of the latter to the former may well be higher than the speed of light. In the real experiment, we observe the transitions with discontinuity as long as about 1cm whereas the characteristic time needed to detect the electrons far beyond the laser spot is as short as less than 10ps.

It is easy to see that the distinct feature of MQS nonlocality is that it can provide signalling for macroscopic distances on the level of an individual quantum process. In fact, we face a nonlocal quantum dynamics which violates the Minkowski model of spacetime with legalization of a deeper non-Lorentz-invariant quantum kinematics advocated by Bell after the Aspect's experiments. This implies a renaissance of Lorentz-Poincare's relativity where the notion of aether seems close to the Bohm's notion of quantum pre-space. As a great benefit, through such renaissance we avoid the quantum dilemma and hence relativity appears to be compatible with de-Broglie-Bohm quantum theory without observer. In a broad sense, we thus come to the Einstein's "God doesn't throw dice" and ultimately open the door to his dream of a unified theory insofar as two most fundamental theories appear to be based on reconcilable realistic concepts.

Some aspects of the work were discussed in [1-2].

1. S. A. Emelyanov, S. V. Ivanov *Evidence for a phase with broken translational symmetry* 30th International Conference on the Physics of Semiconductors (ICPS2010) – Seoul (Korea), July 25-30, 2010.
2. S. A. Emelyanov *Quantum mechanics versus relativity: An experimental test of the structure of spacetime* Physica Scripta **T151**, 014012 (2012).