ER = EPR?

Letter written in response to an article by Juan Maldacena in the November 2016 issue of the Scientific American

Dear editors,

Juan Maldacena's article on "Black Holes, Worm Holes, and the Secrets of Quantum Spacetime" left me in deep embarrassment. Its only nontrivial sentence that I could agree with is that "this picture is still wild speculation" - except that I could not see any justification for the optimism to insert the word "still".

Practically all of quantum mechanics (including the hydrogen atom, but also quite complex many-particle systems) describes entangled systems by means of wave functions that are defined on configuration space, and hence nonlocal. This is a direct consequence of the fundamental quantum superposition principle. QM is indeed far more than Alice and Bob playing qubits - and also far more than the uncertaincy principle. Without all these entangled states, its great and undeniable success would entirely break down. EPR and Bell only suggested specific applications of quantum entanglement in order to demonstrate that it does have (surprising to some) observable consequences, and that the latter cannot simply be the result of some probabilistic "bookkeeping". John Bell furthermore often emphasized that his nonlocality is the same as that known from the entanglement of two electrons in the He atom, for example, - only at a larger distance. So it does NOT require any action at a distance.

It may be true that wormholes - if they did exist and if they were sufficiently stable (which is both highly questionable) - would in principle allow some action at a distance. However, I can neither see how this fact could possibly explain the observed consequences of nonlocal "Bell states", nor how it might justify the further conjecture that "this link (!) is more general", and thus may explain ALL quantum entanglement. Note that it would then also have to explain the very general superposition principle! (In his Romeo and Juliet example, the author is presuming entanglement rather than suggesting another explanation for its consequences.) Black hole entropy, which is often mentioned to argue for a connection with entanglement, is indeed no more than a consequence of the (conceptually presumed) entanglement of field modes in

their quantum ground state beyond horizons - here equivalent to a mutual decoherence of complementary partial volumes in QFT. It does neither require worm holes, nor can it explain non-equilibrium phenomena, such as action at a distance. And … why would we still need quantum gravity if (non-quantized?) spacetime geometry were able already to explain fundamental quantum aspects?

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Here is Maldacena's reply that I did not find very helpful regarding the issue expressed by the title of the article:

The wormholes that I talked about are non-traversable and do not imply an action at a distance. Their properties are similar to entangled states.
The Romeo and Juliet story shows why the wormholes are usual as compared to ordinary entangled states. They are usual because they contain the "interior" where observers who fall into the respective black holes can interact. This shows that the observations that Romeo and Juliet do in the interior are rather unusual from the point of view of the two exteriors.

Regards,

Juan