Contribution ID: **200** Type: **Oral Presentation**

A new Bell inequality for measuring entanglement in relativistic frames.

Tuesday, 5 July 2022 15:45 (15 minutes)

There has been much discussion about quantum entanglement with respect to relativistic frames in the recent literature. By now, the violations of the original Bell's inequality as well as the updated CHSH inequality (as proposed by Clauser et el.) has been well confirmed by experiment. However, this only applies when the relativistic effects are small enough that they can be neglected. As the literature suggests, if relativistic effects are significant, then the Bell correlations, even for entangled pairs, are altered by a relativistic effect called the Thomas-Wigner rotation. The effect is such that relativistic quantum mechanics appears to predict a weakening of the Bell correlations when measured in same directions as in the centre of mass frame and this weakening appears to depend on the relative velocities between the frames. This prediction has led to some disagreement in the literature as to whether Bell inequalities can still be violated in relativistic frames, with some authors believing that the maximum violation of Bell's inequality can still be attained, just in different directions and others believing that you can't. This is of particular interest to some research in the area of quantum technology because there are applications, for example in quantum cryptography, that rely on Bell violations in order to work. The worry is whether these applications can still be applied in relativistic regimes. Our view is that of the former, that maximal Bell violations are still attainable and we introduce a new Bell inequality by adding new variables to the CHSH inequality that compensates for the effect of Thomas-Wigner rotation. Nevertheless, the predictions of relativistic quantum mechanics still violate the upper bound of this new inequality (as derived classically) just like non-relativistic quantum mechanics did for previous iterations of the Bell inequality. The only difference is that the quantum mechanical observable constructed from this new version is not affected by the Thomas-Wigner rotation. We thus believe that this observable can be used as new measure for entanglement in relativistic regimes and any technological applications that require the violation of Bell's inequality can be extended to the relativistic regimes by using these new observables.

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Session Classification: Theoretical and Computational Physics

Track Classification: Track G - Theoretical and Computational Physics