Correlating Space and Time

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"The method we have proposed," says Evgeny Shchukin, "is an extension of the well-known balanced homodyning scheme." However, unlike the standard scheme used for measuring radiation fields, the scheme developed by Shchukin and his professor, Werner Vogel, allows measurement of all normally ordered correlation functions. Their proposal, "Universal Measurement of Quantum Correlations of Radiation," was published by *Physical Review Letters* on May 22nd.

Homodyning is a process that involves a known reference laser, called the local oscillator, to measure the statistical properties of an unknown field: Shchukin explains to *PhysOrg.com*: "Appropriately analyzing the measured data allows us to determine the moments of the radiation field. Knowing the moments (which completely describe a radiation field) helps us to better understand other characteristics of quantum systems."

The method Shchukin and Vogel propose, called balanced homodyne correlation (BHC) technique, has an advantage in that it uses simpler reconstruction procedure for arbitrary space-time correlations. Using an appropriate number of beam splitters and photo-detectors would allow scientists to measure, in principle, the correlations of an arbitrarily high order. This method goes beyond mere homodyne detection into correlation—offering something that can be experimentally applied.

"To my knowledge," Shchukin says, "this is the first approach to experimentally realize such a general correlation measurement."

The beauty of the proposal is that it offers a solution that can be experimentally ascertained. Shchukin explains that it can be used to get a deeper insight into the space-time dependent radiation properties, and on the quantum level: “The data we propose to measure, the moments of the general space time correlations of the field, completely characterize it. They characterize not only the field in one moment of time, but they also describe the whole dynamics of the system and its behavior in time.”

Creating this possible method of measurement has not been easy, though. “What we proposed before was less efficient than the method presented in the paper,” Shchukin says. He explains that he and Vogel had to come up with a way to treat the data in such a manner as to combine it in the proper way to get the desired correlation properties. And they had to find a way to cancel out effects due to noise caused by imperfect detection. BHC can make use of a strong oscillator as the known field, effectively creating conditions in which the signal-to-noise ratio allows for the determination of high-order correlation functions.

Right now, this method has yet to be used in an experiment. However, Shchukin says that there has been some interest in applying this method. The knowledge that could be gleaned from entangled radiation fields would be especially useful in determining the characteristics of such fields, and of taking measurements in order to discover quantum correlations. Shchukin sees this work as a way to open the door to peer into the properties of space-time-dependent correlations of radiation. “If one wants to know the whole dynamics of the system under study, one needs something that allows experimentalists to do that.” And it looks like this might be the way.