

Tuesday, January 30th @ 2pm  
Schwinger Lounge

## “S-matrix positivity without Lorentz invariance”

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**Abstract:** We investigate the analytic structure of scattering amplitudes in theories with broken Lorentz invariance. We do so by studying a UV complete model of relativistic superfluid: a complex scalar with quartic interactions at finite density. We stop at tree level since there are no absolutely stable single-particle states, although the phonons lifetime can be made arbitrarily long at low density or weak coupling. For  $2 \rightarrow 2$  processes in center-of-mass configurations, we confirm the absence of crossing symmetry in its simplest implementation. Due to a non-analyticity in the phonon dispersion relation, a new branch cut appears in the amplitude, at tree level, for unphysical kinematics. The branch point defines a new scale in the problem, which is inversely proportional to the chemical potential. An interesting consequence is a non-decoupling effect in the high energy limit. In the model we study, even derivatives of the forward amplitude are positive while odd derivatives are negative. This pattern can be understood in a general way in the limit of low density, or weak Lorentz breaking.