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UV complete field theory in (2+1)D with symmetry breaking at all temperatures

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It was recently established that spontaneous symmetry breaking can persist at all temperatures in certain biconical $\mathrm{O}(N) \times \mathbb{Z}_2$ vector models when the underlying field theories are asymptotically safe. So far, the existence of such models has only been explored in fractional dimensions for local but non-unitary models or in 2+1 dimensions but for non-local models. In my talk, I will discuss our study of local models at zero and finite temperature directly in 2+1 dimensions employing functional methods. At zero temperature, I show that our approach reproduces the critical behaviour with high accuracy for all $N \geq 2$. I will then exhibit the mechanism of discrete symmetry breaking from $\mathrm{O}(N) \times \mathbb{Z}_2 \to \mathrm{O}(N)$ for increasing temperature near the biconical critical point when N is finite but large. We calculated the corresponding full finite-temperature phase diagram and further showed that the Mermin-Wagner-Hohenberg theorem is respected within this approach, i.e., symmetry breaking only occurs in the $\mathbb{Z}_2$ sector. Finally, we also determined the critical value of N above which this phenomenon occurs to be $N_c \approx 15$.

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