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Making Sense of the Nambu-Jona-Lasinio Model via Scale Invariance

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The status of the chiral-invariant Nambu-Jona-Lasinio (NJL) four-fermi model is quite equivocal. It serves as the paradigm for dynamical symmetry breaking and yet it is not renormalizable. NJL only studied one loop graphs with point vertices, and needed to use an ultraviolet cutoff. We propose to dress the point vertices with scale invariant vertices with anomalous dimensions. We show that if the dimension of the $\bar{\psi}\psi$ fermion mass operator is reduced from a canonical three to a dynamical two, the four fermion interaction becomes renormalizable to all orders in the four-fermion coupling constant. Additionally, we find that dynamical symmetry breaking then occurs with the fermion becoming massive, and we obtain a dynamical massless pseudoscalar Goldstone boson and a dynamical scalar Higgs boson. The Higgs boson mass is automatically of order the dynamical fermion mass, with there thus being no hierarchy problem. The Higgs boson automatically has a width, and the width could serve as a diagnostic to distinguish a dynamical Higgs from an elementary one. We extend the scale invariance to local conformal invariance as then coupled to a gravity theory, conformal gravity, that is conformal too. With Bender and Mannheim having shown that conformal gravity is a ghost-free, unitary theory, it can serve as a consistent theory of quantum gravity. We show that all of the achievements of supersymmetry can be achieved by conformal symmetry and conformal gravity instead, with there then being no need for any new particles at the LHC.

Author: MANNHEIM, Philip (University of Connecticut)

Presenter: MANNHEIM, Philip (University of Connecticut)

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