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Non-perturbative aspects of Sp(2N) gauge theories.

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The discovery in 2012 of the Higgs boson provided evidence for our understanding of the origin of mass. However there still remain some unanswered questions one of which is the "Naturalness Problem".

Like the other fundamental particles, the Higgs acquires loop corrections to its mass due to its interaction with the quarks, the leptons and itself. If we impose an ultraviolet cutoff, $\Lambda_{\rm UV}$, on the Standard Model, these corrections depend quadratically on $\Lambda_{\rm UV}$. If $\Lambda_{\rm UV}$ is sent to infinity, a very large counter term is required to cancel out the quadratic divergence arising from the loop corrections. In order to produce the small observed Higgs mass of 125 GeV, the counter term must be computed to a precision so high that it is not only unnatural - hence the name - but far beyond experimental reach.

One way to resolve this problem is to treat the Higgs not as a fundamental particle but as a constituent one (like the proton or neutron). The need for fine-tuning is simply an effect of the approximation of the Higgs as a fundamental particle breaking down.

The compositeness deals with the issue of fine tuning and the subsequent low mass is achieved by corollary of Goldstone's Theorem. When a symmetry is explicitly broken (e.g. by a mass term) there exists a light boson for each broken generator (as opposed to a massless boson in the case of spontaneous symmetry breaking). The explicit breaking of a new symmetry group could give rise to what is observed as the Higgs boson.

The combination of Goldstone's Theorem and a new symmetry group have potential to explain the low-mass Higgs as a composite particle without the need for fine-tuning. Candidate symmetries are the Symplectic Groups (denoted as Sp($2N$)). Observable quantities of such a Quantum Field can be computed on the lattice and their experimental detection would provide evidence for same.

Primary author: HOLLIGAN, Jack (Swansea University)

Presenter: HOLLIGAN, Jack (Swansea University)