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The massless limit and tension in massive gauge theories

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We study massive non-linear gauge theories with mass added by hand. First, we consider the massive Yang-Mills theory. The standard perturbative approach suggests that the massless limit of this theory is not smooth. Nevertheless, we show that the longitudinal modes - the source of this discontinuity - become strongly coupled at the Vainshtein scale. Beyond it, we show that the massless theory is recovered up to small corrections and that the massless limit of the massive Yang-Mills theory is smooth. We then extend our study to the theories of massive Kalb-Ramond and Proca fields modified by a quartic self-interaction and show that the same strong coupling scale is present in both theories. In the Proca theory, the longitudinal mode enters the strongly coupled regime beyond this scale, while the two transverse modes propagate further and survive in the massless limit. In contrast, in the case of the massive Kalb-Ramond field, the two transverse modes become strongly coupled beyond the Vainshtein scale, while the pseudo-scalar mode remains in the weak coupling regime and survives in the massless limit. This indicates a contradiction with numerous claims in the literature that state that the massive Kalb-Ramond and Proca theories are dual to each other.

Presenter: Ms HELL, Anamaria (LMU Munich)