Discovery of the complexity of the quark, a fundamental constituent of matter

Assigning a chaos index for dynamics of generic quantum field theories is a challenging problem because the notion of a Lyapunov exponent, which is useful for singling out chaotic behavior, works only in classical systems. We address the issue by using the AdS/CFT correspondence, as the large N_c limit provides a classicalization (other than the standard $\hbar \to 0$) while keeping nontrivial quantum condensation. We demonstrate the chaos in the dynamics of quantum gauge theories: The time evolution of homogeneous quark condensates $\langle \bar{q}q \rangle$ and $\langle \bar{q}\gamma_5 q \rangle$ in an N=2 supersymmetric QCD with the $SU(N_c)$ gauge group at large N_c and at a large 't Hooft coupling $\lambda \equiv N_c g^2_{YM}$ exhibits a positive Lyapunov exponent. The chaos dominates the phase space for energy density $E \gtrsim (6\times10^2)\times m^4_q(N_c/\lambda^2)$, where mq is the quark mass. We evaluate the largest Lyapunov exponent as a function of (N_c,λ,E) and find that the N=2 supersymmetric QCD is more chaotic for smaller N_c.