# Squeezing, trisqueezing, and quadsqueezing in a spin-oscillator system

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Higher-order nonlinear interactions on a quantum harmonic oscillator lead to increasingly nonclassical and resourceful quantum states. However, studying these interactions has been challenging as they typically become exponentially weaker with increasing order. Using the motion of a trapped ion coupled to its spin, we implement a new protocol relying solely on linear spin-dependent interactions to generate up to fourth-order interactions. Focusing on generalised squeezing, we demonstrate and characterise squeezing, trisqueezing, and quadsqueezing interactions; the fourth-order quadsqueezing interaction is over 100 times stronger than possible with conventional methods. Our approach imposes no fundamental limit on interaction order and applies universally to platforms supporting spin-dependent linear interactions. Strong higher-order nonlinear interactions unlock the study of fundamental quantum optics, quantum simulation, and computation in a hitherto unexplored regime.