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Weak integrability breaking and level spacing distribution

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Recently it was suggested that certain perturbations of integrable spin chains lead to a weak breaking of integrability in the sense that integrability is preserved at the first order in the coupling. Here we examine this claim using level spacing distribution. We find that the volume dependent crossover between integrable and chaotic level spacing statistics which marks the onset of quantum chaotic behaviour, is markedly different for weak vs. strong breaking of integrability. In particular, for the gapless case we find that the crossover coupling as a function of the volume L scales with a $1/L^2$ law for weak breaking as opposed to the $1/L^3$ law previously found for the strong case.

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