Effect of bifurcation on quantum correlations

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Quantum correlations reflect the quantumness of a system and are useful resources for quantum information and computational processes. Even though these measures of quantum correlations do not have a classical analog still they are influenced by the underlying classical dynamics of the given system. In this work, a quantum kicked-top which collectively models a multi-qubit system is studied [1]-[2]. Its classical limit shows a regular to chaotic transition via period-doubling bifurcation route as the chaoticity parameter k is increaseed from zero onwards. Effects of this classical bifurcation (refer Fig. 1) on the measures of quantum correlations such as quantum discord (D), geometric discord (D^G) and Meyer and Wallach Q measure is studied [3]. Quantum discord is the difference between the total quantum correlations and the classical correlations between two subsystems [3]. While geometric discord is the distance between the quantum state and the nearest classical state [3]. It is found that the slope of these measures as a function k changes at the bifurcation point $k = 2$ (refer Fig. 2) [4]. We have used random matrix theory to model the globally chaotic case ($k > 6$) and numerically it is found that the time averages of these correlation measures in both the cases are in good agreement with each other. We have studied the scaling of these measures as a function of total spin (j) of the multi-qubit system for the cases when the classical phase space structure is regular and globally chaotic.

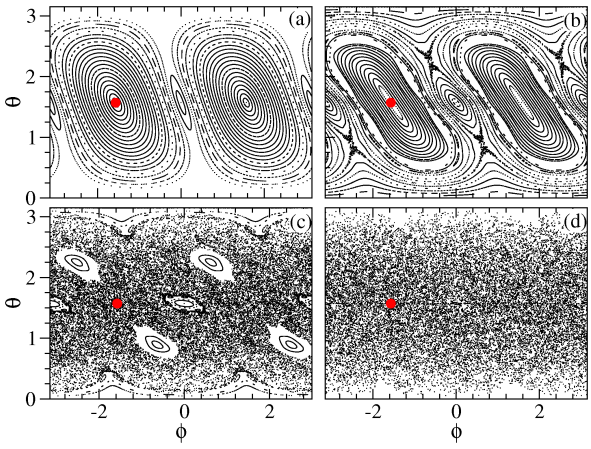

Figure 1: Phase-space pictures of the classical kicked-top for $p = \pi/2$ and (a) $k = 1$, (b) $k = 2$, (c) $k = 3$ and (d) $k = 6$. Red filled circle in all the graphs marks the position of the coherent state for which time average of correlation measures (plotted in Fig. 2) are calculated.

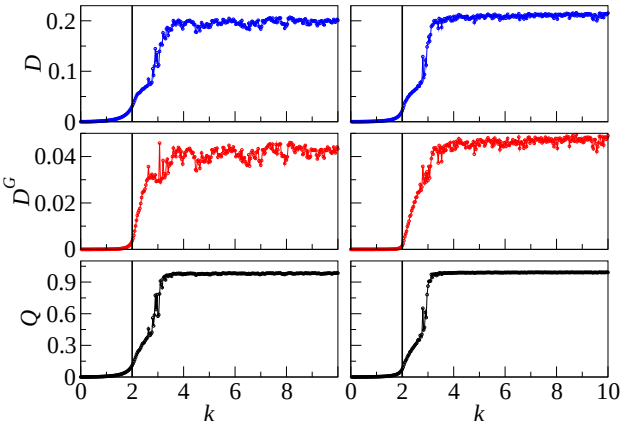

Figure 2: Time averaged discord (D), geometric discord (D^G) and Q measure as a function of k for $p = \pi/2$. Left (right) column is for $j = 50$ ($j = 120$). Time average is carried out over 500 time steps. Vertical line marks the position of bifurcation at $k = 2$.

References

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