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Controllability and weak conical connectedness of the spectrum for control-affine quantum systems

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We explore the controllability of a closed control-affine quantum system driven by two external fields. The controllability properties of such a system are known to be closely related to its spectrum, seen as a function of the control. Previous studies have demonstrated that a spectrum connected by non-overlapping conical intersections yields exact controllability in the finite-dimensional case and approximate controllability in the infinite-dimensional case. Generically, intersections between two eigenvalues are conical and non-overlapping. However, in physical situations, due to symmetry of the system, the spectrum can exhibit both conical and semi-conical intersections, with some intersections overlapping. We refer to this as a "weakly conically connected"spectrum. We show that when the overlapping intersections have "rationally unrelated germs"at each intersection point, the same controllability properties can still be obtained. Finally, we provide a testable first-order sufficient condition for controllability.

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