Rydberg excitation of trapped cold ions: a detailed case study

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We present a detailed theoretical and conceptual study of a planned experiment to excite Rydberg states of ions trapped in a Paul trap. The ultimate goal is to exploit the strong state-dependent interactions between Rydberg ions to implement quantum information processing protocols and simulate the dynamics of strongly interacting spin systems. We highlight the promise of this approach when combining the high degree of control and readout of quantum states in trapped ion crystals with the novel and fast gate schemes based on interacting giant Rydberg atomic dipole moments. We discuss anticipated theoretical and experimental challenges on the way to its realization.

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