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Rydberg molecules mediated interaction between polar molecules: a new tool to realize two-qubit gates ELENA KUZNETSOVA, University of Connecticut, SETH RITTENHOUSE, ITAMP, Harvard-Smithsonian Center for Astrophysics, SUSANNE YELIN, University of Connecticut, HOSSEIN SADEGHPOUR, ITAMP, Harvard-Smithsonian Center for Astrophysics — We propose and analyze coherent coupling of ground state polar molecules and Rydberg atoms as a way to enhance the interaction strength between molecules. Ultracold polar molecules placed in periodic arrays of traps represent an attractive system for quantum information processing. Polar molecules that can be currently produced at ultracold temperatures by Feshbach and photo-association are limited to alkali dimers, having permanent dipole moments of the order of 1 Debye. It limits the distance at which molecules can efficiently interact via dipole-dipole interaction to 100 nm, i.e. to a few nearest neighbors. The interaction strength can be significantly increased by coupling molecules to Rydberg atoms, a process in which they form a Rydberg molecule. The states of a Rydberg molecule can have dipole moments of thousands Debye, increasing the effective interaction distance up to several μm. The Rydberg molecular states depend on the initial state of a polar molecule, allowing to realize state-dependent interaction between them. We analyze the feasibility of performing a phase gate with KRb and RbCs molecules coupled to Rb Rybderg atoms.

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