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**Consequences of Zeeman Degeneracy for van der Waals Blockade between Rydberg Atoms**[1] THAD WALKER, MARK SAFFMAN, University of Wisconsin-Madison — We analyze the effects of Zeeman degeneracies on the long-range interactions between like Rydberg atoms, with particular emphasis on applications to quantum information processing using van der Waals blockade. We show how degeneracies affect the primary error sources in blockade experiments, in particular that blockade errors are sensitive primarily to the weakest possible atom-atom interactions between the degenerate states, not the mean interaction strength. We present van der Waals potentials in the limit where the fine-structure interaction is large compared to the atom-atom interactions. For most angular momentum channels there are one or more superpositions of Zeeman levels that have extremely small dipole-dipole interactions and are therefore poor candidates for effective blockade experiments. Other channels with promising properties are identified and discussed. We combine the blockade and van der Waals results to quantitatively analyze the angular distribution of the blockade shift and its consequence for blockade experiment geometries of particular interest.

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