Ultracold Rydberg gases are a promising system for exploring many ideas in the area of quantum computation, quantum optics, novel states of matter, and many-body physics. A key to understanding ultracold Rydberg gases and making progress in these exciting directions is to understand how Rydberg atoms interact with other atoms. We will review our understanding of Rydberg interactions including the effect of external fields. We will focus on describing interactions that lead to 2 types of novel molecule formation, so called ‘trilobite’ molecules and macrodimers. We have recently observed ‘trilobite’ molecules in an ultracold Cs gas and found that these molecules possess dipole moments in excess of 30 Debye. In prior work, we detected electric field tunable Cs macrodimer molecules, molecules with bond lengths of ~5 microns. In this talk, we will compare and contrast these exotic forms of matter as well as try to place their study in the context of understanding Rydberg atom interactions quantitatively.

**ABSTRACT:**

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Visiting Fellow, Steacie Institute for Molecular Sciences, National Research Council, Ottawa, Canada 1999-2001

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