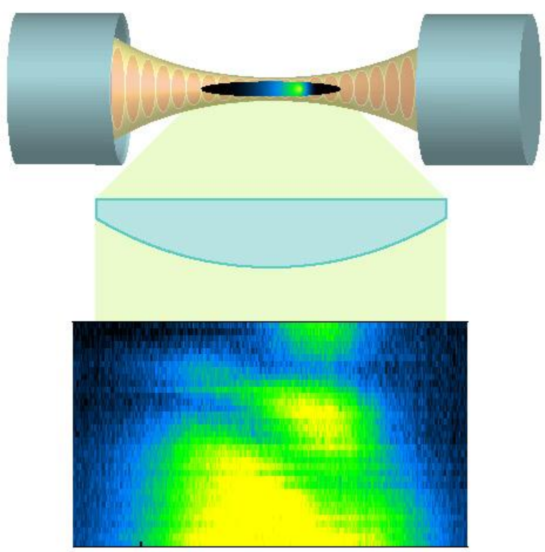
Watching Photons Play with Magnets

Interactions that arise in nature, such as gravitational or electromagnetic interactions, are typically local, meaning that they decay with increasing distance. For example, consider the force between a refrigerator and a magnet; the magnet only sticks if held very close to the fridge. Now imagine if the magnet were instead most strongly attracted to the fridge from across the kitchen — if the magnetic force could act non-locally. Such non-local interactions theoretically offer opportunities for investigating how information is "scrambled" in black holes, testing new paradigms for computation, and developing ultra-precise sensors.

A team of researchers at Stanford University has generated non-local interactions between thousands of atoms in the laboratory by inducing light to convey information between them. Davis et al. encoded quantum information in the atoms' magnetic moments (spins), which can point either up or down. When a single photon is emitted by one atom and absorbed by another, one atom's spin is flipped up only if the other's is flipped down. By directly observing the flip-flop effects in a sequence of images, the researchers showed that they had created an interaction that did not decay with the distance between atoms but was governed instead by the intensity pattern of a laser field. They identified a way of using these non-local interactions to generate correlations between spins in different places, which opens the door to creating new quantum mechanical states. The researchers even showed how to tune the interactions to be either attractive or repulsive. In future experiments, this capability could allow the researchers to "rewind time" for the atoms in the experiment — like letting a magnet come unstuck from the fridge.



Reference: E. Davis, G. Bentsen, L. Homeier, T. Li, and M. Schleier-Smith, "Photon-Mediated Spin-Exchange Dynamics of Spin-1 Atoms." *Physical Review Letters* **122**, 010405 (2019).