In radio and telecommunications, a classical dipole antenna consists of two poles into which radio frequency current flows [1]. An oscillating current (usually a semi-sinusoidal wave) drives the two poles of an antenna, creating a transmitter. The transmitter broadcasts the varying electric field, which is later picked by the two poles of a receiver antenna. This process can be viewed as a macroscopic example of coherence transfer as well as energy transfer via DD interactions. Similar cases are also found in photosynthesis, a process of light-harvesting antennas transferring light photon energy via DD interactions in molecules [2].

In quantum physics, suppose a Rydberg atom has a superposition state composed of state *s* and state *p*: , where *E* is the energy gap between state *s* and *p.* The dipole moment of this atom is . As the wavepacket evolves, the dipole moment of this atom is changing periodically or “oscillating”, very similar to a classical dipole transmitter. It would be very interesting to find a way of creating a microscopic “receiver” so that the wavepacket motion on one atom transfers to anther.

We propose a pair of atoms, similar to the system described in [3], to show such a transfer process. One of the atoms starts from a wavepacket composed of eigen state and , and it acts as a “transmitter”. The other one starts from an eigen state and acts as a “receiver”. There is a resonant energy transfer through DD interactions: ↔. At time 0, the wavefunction of this pair is:

The driving current from the transmitter is applied, or for receiving antennas the output signal to the receiver is taken, between the two poles of the antenna.

Two identical, temporally delayed wavepackets are produced by exposing the atom to two phase-coherent pulses. By measuring the degree of interference between the initial ‘pump’ wavepacket and the delayed ‘probe’ wavepacket, the time evolution of the initial wavepacket in the atom potential can be followed. The first wavepacket evolves in time and the degree of interference with the delayed probe pulse is determined by the spatial overlap of the two wavepackets. If the two wavepackets overlap in space and are in phase, they interfere constructively; The amplitudes add up and the coherent total Rydberg population will be four times as high. If the wavepackets overlap but are out of phase, the amplitudes cancel and there is no resulting Rydberg population. If there is no spatial overlap between the ‘pump’ and ‘probe’ wavepacket they will not interfere, irrespective of the phase difference: The resulting incoherent Rydberg population after two pulses is twice the population after a single pulse.

[1] Steve Winder, Joseph Carr, Newens Radio and RF Engineering Pocket Book, 3rd edition, Newens, (2002).

[2] Beverley. R. Green, Jan. M. Andersion, W.W. Parson, Light-Harvesting Antennas in Photosynthesis, Springer Netherlands (2003).

[3] F. Robicheaus, J. Phys. B: At. Mol. Opt. Phys. 43 (2010).