Optical Forces on Helium with Pulsed Laser Light

Alexander Sage, John Elgin, Harold Metcalf

Introduction

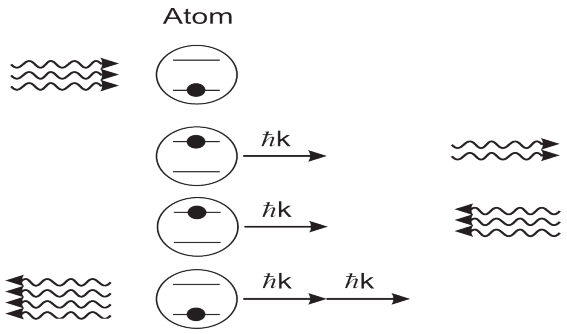

Figure 1

ARP works by exciting an atom to an upper state with a pulse of light from one direction and bringing it back down to the original state with another pulse of light from the opposite direction.

The absorption of light results in a force caused by a gain of momentum from the light. The emission of the same light in an opposite direction causes another momentum push in the same direction resulting in two impulses shown. The force can be increased by changing the rate at which this transition occurs.

Pulse Arrangement

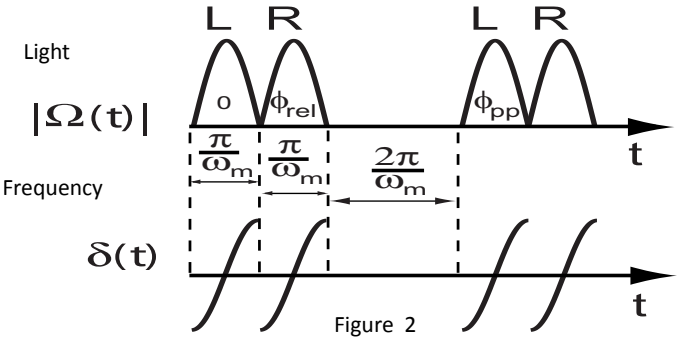

Figure 2

The first pulse (L) causes absorption, the second pulse (R) stimulates emission, and the cycle repeats after a period of dead time. Pulse (R) starts just as pulse (L) is ending so that the change in excited states of the electron is as fast as possible.

Experimental Setup

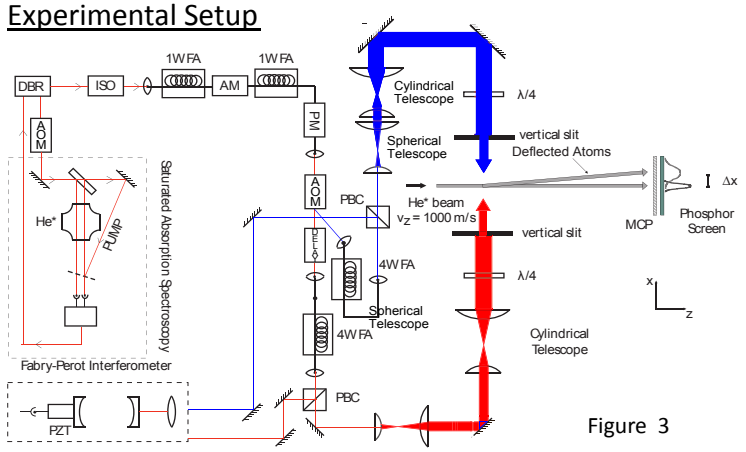

Figure 3

Helium Atom

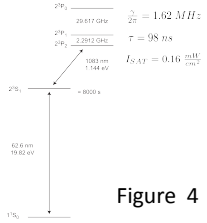

Figure 4

The helium atoms start at the ground state and are excited to the first triplet state (vertical arrow). Then the light excites the electron to the higher state (horizontal arrow).

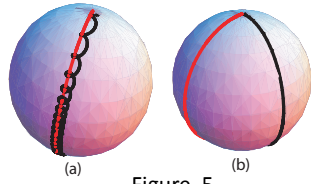

Figure 5

Figure 5 is of the Bloch sphere; a useful tool to imagine the transition between atomic states. The left shows the standard transition of ARP from ground to excited states. The right shows the more direct path of ARP that we use.

Adiabatic Rapid Passage (ARP) is a method used to greatly surpass the regular radiative force, which relies on spontaneous emission of light. To achieve ARP, the parameters of the light must be carefully manipulated to allow for absorption and stimulated emission at a rate significantly faster than the natural decay time.

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