ATTOSECOND COHERENT CONTROL OF VIBRATIONAL WAVEPACKETS

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The coherent control of quantum wavepackets (WP) is going to open a new realm of science and technology and covers widely ranging fields such as coherent control of chemical and biochemical processes, development of optical functions of nano-structures, new coherent light sources, quantum information and transportation engineering, quantum computing, and so on. The WP interferometry (WPI) is the most fundamental method in the WP manipulation. However, WPI with 100% contrast has never been measured so far on atoms and molecules. Our WPI technique lays its heart in controlling quantum phases of WPs with attoseconds accuracy. We have recently achieved almost 100% contrast in nuclear WPI by means of the double-pulse pump/control method. The inter-pulse-delay is tuned with accuracy better than 5 attoseconds. Model calculations have been made also to study the interaction of two nuclear WPs aiming at searching coherent control methods of encoding and decoding specific information on a molecule.

The WPI measurements have been done on the Hg-Ar van der Waals (vdW) complex generated in a supersonic jet. Two identical fs laser pulses (254nm, 300fs) are used to create and control the WPs The pulses excite the Hg-Ar from the $v = 0$ level of the ground X state to the bound levels of the $A\ ^3 0^+$ state. A nuclear wave packet of the Hg-Ar stretching vibration is created by a coherent superposition of the eigenfunctions ($v = 3, 4,$ and 5 levels) of the A state.

The two fs laser pulses are generated from one fs pulse by using a Michelson-type double arms optical stage. A fine control of the delay is achieved by changing the pressure of a H_2 gas cell placed in one of the arms. The two nuclear WPs interfere constructively or destructively depending on their relative phase, which is controlled with attoseconds accuracy by changing the H_2 pressure. Results of the WP interference are observed through the laser induced fluorescence (LIF) detection of changes in the $v = 3, 4,$ or 5 level population at 30 ns later of the fs double pulses. The excited level population exhibits oscillations against a change in the delay time as shown in Fig. 2. The oscillation occurs with a period of about 0.848 fs in harmony with the fs laser frequency. Model calculations to simulate the WPI results will be shown together with calculations of WP encoding.

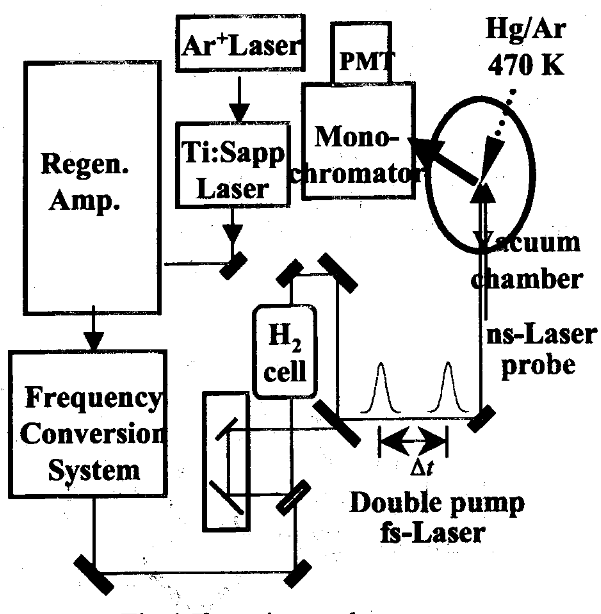

Fig.1 Experimental setup

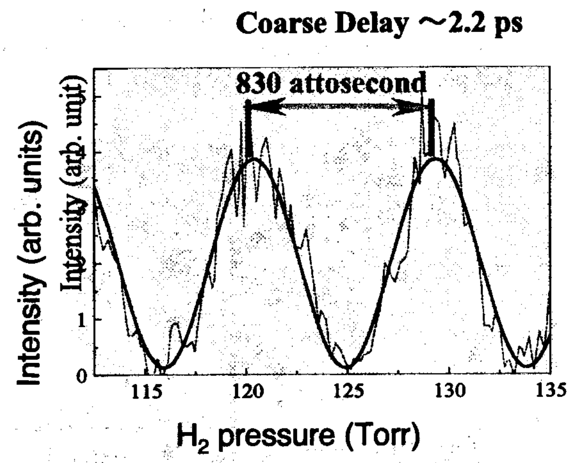

Fig. 2 Interferometry of the Hg-Ar vibrational wavepacket on the A state. Change in the H_2 pressure is calibrated to the time scale by the optical interferometry of the two fs laser pulses.