L.9: Two-isotope magneto-optical trap for noble gas Krypton atoms

Among several applications of laser cooled metastable Krypton atoms, study of cold collisions and penning ionization provide an insight to the inter-atomic interactions in metastable state. Inter-atomic interactions, either in the absence or in presence of near resonant light, are manifested in the cold atom collision process. In cold collisions, where colliding atoms have de-Broglie wavelength comparable or larger than the range of inter-atomic potential, only few partial waves can account for the collision cross section. This makes interpretation of experimental data easier. Further, cold collisions may involve two similar (homonuclear) or different (heteronuclear) atoms, with different dynamics of collision in both the cases. Recently, the study of heteronuclear cold collisions has shown promise in the production of polar molecules which have applications in chemistry, meteorology and quantum physics.

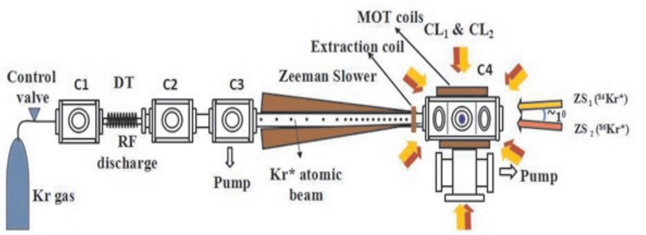

Fig. L.9.1: Schematic of the experimental setup for TIMOT of metastable Kr atoms. C1: Kr gas inlet chamber, C2: observation chamber, C3: pumping chamber, ZS: Zeeman Slower, MOT: magneto-optical trap.

A magneto-optical trap (MOT) is a versatile tool to produce cold atoms in the temperature range of few hundreds of micro-Kelvin for the study of cold collisions. This trap is formed by applying three pairs of counter propagating laser beams in the presence of an inhomogeneous magnetic field. A two isotope magneto-optic trap (TIMOT) to cool and trap ^{84}Kr and ^{86}Kr istotopes of Krypton simultaneously has been made operational recently in Laser Physics Applications Section at RRCAT. The setup has been finally utilized for the study of the hetronuclear cold collisions in ^{84}Kr and ^{86}Kr isotopes.

The schematic diagram of this in-house developed setup for TIMOT is shown in Fig. L.9.1. Laser cooling of Krypton atoms is performed in the metastable state $5s[3/2]_2$ (denoted as Kr*) which has lifetimes of ~ 40 seconds. The excitation of atoms to this state is achieved by radio frequency (RF) excitation method. The laser cooling of metastable state isotopes ^{84}Kr* and ^{86}Kr* need different lasers with a frequency difference of ~65 MHz at ~811.5 nm wavelength. These lasers drive the cooling transitions in these isotopes between the states $5s[3/2]_2$ and$5p[5/2]_3$. The TIMOT is loaded from a slow atomic beam of metastable state Kr (Kr*) atoms. This slow atomic beam is formed when Kr gas from RF discharge tube (DT) flows through a collimator tube, chambers C_2 and C_3 and a Zeeman slower device (Fig. L.9.1). All the chambers are maintained at different pressure values. Two intense laser beams (ZS_1 and ZS_2) at two different frequencies are used for the cooling of atomic beam in the Zeeman slower for both the isotopes ^{84}Kr* and ^{86}Kr*. These beams were kept at small angles from the Zeeman slower axis to avoid destruction of the MOT clouds by beams. The number of atoms in the TIMOT for ^{84}Kr* and ^{86}Kr* were varied by varying the laser cooling detuning with respect to the cooling transitions of the corresponding isotopes.

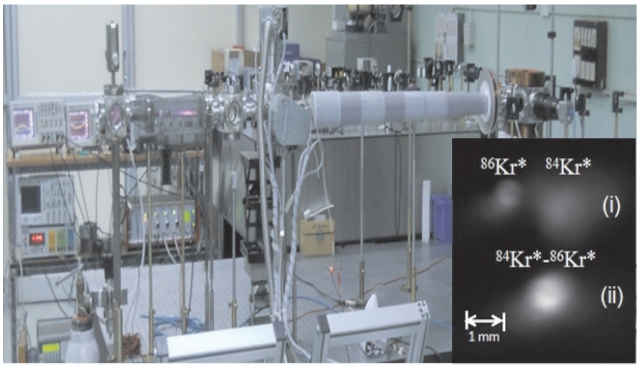

Fig. L.9.2: Photograph of experimental setup for cooling and trapping of Kr atoms in TIMOT. The inset shows the CCD fluorescence images of separated and overlapped clouds of cold Kr atoms.*

The photograph of the experimental TIMOT setup is shown in Fig. L.9.2. The inset of Fig. L.9.2 shows the fluorescence images of the separated and overlapped clouds of Kr* atoms in the MOT. Nearly 10^5 atoms at temperature of around ~300 μK of each isotope were trapped in the TIMOT. This TIMOT setup was used to measure the cold collision loss rate due to ^{84}Kr* and ^{86}Kr* collisions.

We have investigated the heteronuclear collision trap loss rates for each isotope due to the presence of cold atoms of other isotope using the TIMOT loading curves. The two body heteronuclear loss rate coefficient $\beta_{^{84}Kr^{*}\_^{86}Kr^{*}}$(i.e. for the loss of ^{84}Kr* due to presence of ^{86}Kr*) is measured to be (8.7±0.8) x 10^{-10} cm^3/s for laser beam intensity values of 21 mW/cm^2 (for cooling of ^{84}Kr*) and 64 mW/cm^2 (for cooling of ^{86}Kr*).

For more details of this work please refer to *S. Singh et al., J. Phys. B: At. Mol. Opt. Phys. 48 (2015) 175302.*

Reported by:
H. S. Rawat (hsrawat@rrcat.gov.in)