

Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: 2498

Type: Oral (Non-Student) / Orale (non-étudiant(e))

## Quantum Diffractive Collision Universality and the Quantum Pascal

Wednesday 5 June 2019 11:15 (15 minutes)

Cold atoms have revolutionized experimental physics, leading to breakthroughs ranging from the creation of new states of quantum matter to the redefinition of the primary SI units. In our work, we have been studying collisions between cold Rb atoms held in a magnetic trap and room temperature background gas particles. These collisions are particularly interesting owing to the fact that they include long-range (high impact parameter and high angular momentum) interactions which impart very little momentum to the trapped atoms, so-called quantum diffractive (QD) collisions. Cold, trapped atoms have low momenta and large de-Broglie wavelengths, making them excellent detectors for quantum diffractive collisions. The small momentum changes are measured through the loss rate of the "sensor" atoms from shallow magnetic traps, whose depths, U, can be varied. Namely, the variation of the loss rate with trap depth is a momentum spectrometer. In this talk, I will present our recent discovery of a new class of universality which describes the velocityaveraged loss rate coefficient associated with QD collisions,

 $\langle \sigma_{\rm loss} v \rangle = \langle \sigma_{\rm tot} v \rangle \left[ 1 - \sum_j \beta_j \left( \frac{U}{U_d} \right)^j \right].$ 

Here,  $\langle \sigma_{tot} v \rangle$  is the velocity averaged total cross-section,  $U_d = 4\pi\hbar^2 v_p/(m_t \langle \sigma_{tot} v \rangle)$  is a characteristic energy scale for quantum diffractive collisions,  $m_t$  is the mass of the trapped atom, and  $v_p$  is the most probable speed for the room temperature background particle. The  $\beta_j$  coefficients are universal, characterising the nature of the QD collision interaction. That is, each form of long-range interaction,  $-C_n/R^n$ , are a different class of universality with unique  $\beta_j$ . This universality has been demonstrated for atom-atom (Rb-X, X = He, Ar, Xe) and atom-molecule (Rb-X, X = H<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>) collisions, characterized by a long range potential of the form  $-C_6/R^6$ . This breakthrough has allowed us to define the "quantum pascal", a definition of the Pascal based on the *measured* velocity average total collision cross-sections and on immutable atomic properties.

Authors: Dr BOOTH, James (BCIT); Mr SHEN, Pinrui (UBC); Prof. KREMS, Roman (UBC); Prof. MADISON, Kirk (UBC)

## Presenter: Dr BOOTH, James (BCIT)

**Session Classification:** W1-1 Degenerate Quantum Gases and Cold Atoms and Molecules (DAMOPC/DCMMP) | Gaz quantiques dégénérés, molécules et atomes froids (DPAMCP/DPMCM)

**Track Classification:** Division of Atomic, Molecular and Optical Physics, Canada / Division de la physique atomique, moléculaire et photonique, Canada (DAMOPC-DPAMPC)