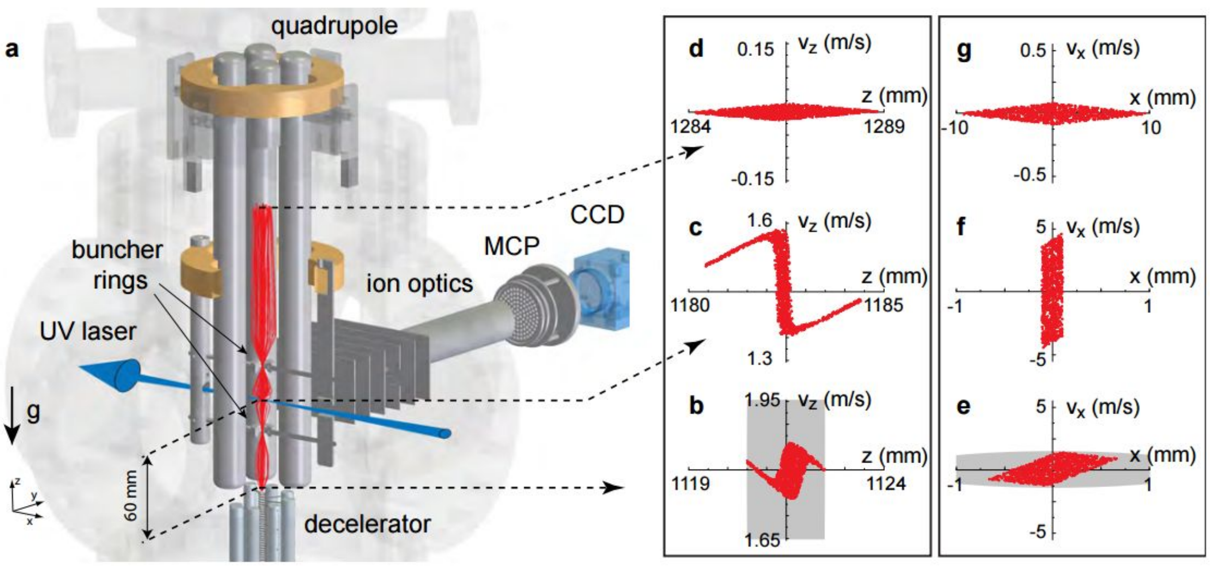
Molecular fountain my lead to more precise measurement of physical constants

January 18 2017, by Bob Yirka



Experimental set-up with simulated trajectories. a. Schematic view of the top part of the vertical beam machine showing the end of the traveling wave decelerator and the quadrupole lens system. The quadrupole lens consists of 4 cylindrical rods suspended by 2 ceramic discs. Two ring electrodes focus molecules in the z-direction. For a view on the inside, part of the quadrupole and the buncher has been cut. Molecules are ionized by a UV laser and imaged on a phosphor screen located behind a multi channel plate (MCP). The image is recorded using a charge coupled device (CCD) camera and a photo-multiplier tube (not shown). The red curves show a simulation of trajectories through the lens system for a beam launched with a velocity of 1.8 m/s. b-g Phase-space plots showing the acceptance of the setup in both the longitudinal (b-d) and transverse directions (e-g), at three different heights. Note that the axes of panel g are scaled by a factor of 10 compared to panel e and f. The grey ellipses show the distribution of the packet of molecules at the exit of the decelerator. Credit: arXiv:1611.03640 [physics.chem-ph]

(Phys.org)—A team of researchers at Vrije Universiteit Amsterdam has built, for the first time, a molecular fountain. The group has published a paper in the journal *Physical Review Letters* describing how they created the fountain, how it works and their ideas on how it might be used to more precisely measure physical constants.

Scientists developed atomic fountains back in the 1980s and since that time they have been applied to a myriad of applications, the most well-known example likely being the atomic clock. The purpose of an atomic fountain is to allow for measuring the characteristics of atoms moving at relatively slow speeds. The slowed speeds are due to the way the fountain works—atoms are cooled to a very low temperature and are then shot upwards where they eventually slow, stop and begin to fall due to the force of gravity. An atomic clock works by setting an atom's internal state before it is shot upwards and then noting the minute change to its internal state as it comes back down. Scientists would like to have access to a similar fountain that works at the molecular level, because they believe it could be used to more accurately measure physical constants, which in turn could help in stringent testing of the Standard Model. Unfortunately, until now, that was not possible because of the difficulty in cooling molecules without causing them to spread out. In this new effort, the researchers have overcome that problem.

To create the molecular fountain, the researchers cooled ammonia molecules by combining two prior techniques and applying them to a molecular beam. The first involved applying voltages in a rapidly switching manner to remove energy from the beam. The second involved applying high voltage that was smoothly varied to allow for continually slowing the potential of the beam as well as its speed. Once the molecules were slowed in a trap, they were fired upward in such a way as to cause them to undergo changes in velocity and position. They were then ionized by a laser and measured by a detector disk.

The device is not yet able to offer physical constant measurements, however, because it is only able to detect a single molecule for every five repetitions of the fountain blast, which works out to less than one detection per second. This means that it will take a lot of time to gather enough information from a single fountain to make any real measurements. Fortunately, as more repetitions will produce additional data, which suggests highly precise measurements are sure to come in the near future.

More information: Cunfeng Cheng et al. Molecular Fountain, *Physical Review Letters* (2016). DOI: 10.1103/PhysRevLett.117.253201 , On *Arxiv*: arxiv.org/abs/1611.03640

ABSTRACT

The resolution of any spectroscopic or interferometric experiment is ultimately limited by the total time a particle is interrogated. Here we demonstrate the first molecular fountain, a development which permits hitherto unattainably long interrogation times with molecules. In our experiments, ammonia molecules are decelerated and cooled using electric fields, launched upwards with a velocity between 1.4 and 1.9 m/s and observed as they fall back under gravity. A combination of quadrupole lenses and bunching elements is used to shape the beam such that it has a large position spread and a small velocity spread (corresponding to a transverse temperature of

Citation: Molecular fountain my lead to more precise measurement of physical constants (2017,

January 18) retrieved 1 May 2024 from https://phys.org/news/2017-01-molecular-fountain-precise-physical-constants.html