

December, 2008**Vol.005****In this issue**

- Student's Question of the Day
- New Research
- Not wonder, this is Physics
- News Bulletin
- Photo Gallery

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Student's Question of the Day**What is photo-detachment of negative ions?**

Photo-detachment is a process in which an electron is removed from a negative ion by a laser light. Most information on the structure of a negative ion and the external field's effect on it, have been obtained by studying the photo-detachment process. It is an important example of fundamental process where light and matter interact. Such process occurs in nature all the time e.g. in stellar and planetary atmosphere, interstellar nebulae and plasma etc. This process has been progressing both by an interaction of experimental observations and theoretical description of a negative ion. First we briefly discuss negative ions and then photo-detachment process in detail.

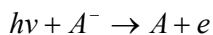
An atom or a molecule having an excess of electron is usually known as a negative ion. They are formed in attachment process in which an additional electron is captured by an atom or a molecule. Negative ions play an important role in a

wide range of process of physical and practical interest.

Many important biological processes and chemical reactions involve negative ions. Binding energies of negative ions are used as input parameters to model ionic crystals. Negative ions are known to have a very significant impact on the properties of plasmas, in particular the electrical conductivity. Most of the mobile negative charge in Earth's middle atmosphere is carried by negative ions. Negative ions also have astrophysical significance, being found in the atmosphere of stars in the intergalactic medium. Chandrasekhar, a Nobel laureate has shown that the hydrogen negative ion is an important prototype in atomic physics and astrophysics.

Photo-detachment is a process analogous to photo-ionization that ejects an electron from a negative ion. But in the photo-detachment a significantly smaller energy is needed to detach an electron than in the photo-ionization. For example 13.6 eV

energy is required to ionize hydrogen atom, while only 0.754 eV energy is needed to detach the hydrogen negative ion. Schematically, Photo-detachment process can be written as:



and its schematic diagram is as under:

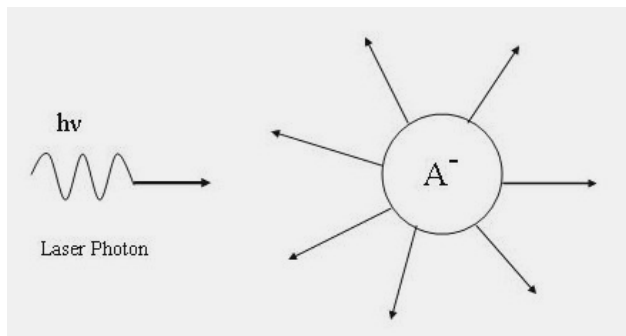


Figure: Schematic diagram of Photo-detachment process

When a Photon of energy $h\nu$ is made incident on a negative ion A^- , the electron is emitted in all possible angles as shown by outgoing arrows in the figure above. Quantum mechanically we say that electron waves coherent in nature are originating in all possible directions from the coherent source after detachment. These outgoing waves then propagate away from the ion core according to the semi-classical mechanics and these are correlated with classical trajectories. At very large distance from the source, the total photo-detachment probability (total cross section) and the angular distribution (differential cross section) of the detached electrons are measured as a function of laser photon energy. These cross sections are very important in atomic and molecular physics to infer the structural information and external field's effects. Differential cross section provides

information about wave function of the negative ion and the interferences in the total cross section provides information about the external fields to the system.

Different analytical techniques have been used to investigate these cross sections as a function of incident photon energy. The Closed-orbit Theory, Two-center Model and the Theoretical Imaging Method are very helpful for this purpose. The Closed-orbit Theory is a semi-classical approach to the negative ion photo-detachment spectra. It gives the total cross-section as a sum of two terms, one a smooth varying part (as a function of energy) and the other a superposition of sinusoidal oscillations. Each oscillation is associated with a closed orbit starting at and returning to the nucleus. It is therefore possible to analyze a given photo-detachment spectrum in terms of the closed orbit contributing to it.

For the description of diatomic negative ion, we use Two-center Model in which each center behaves as a coherent source of electron waves. The calculations for cross sections provide us the information about the distance between two atoms in a diatomic molecule. In the presence of an external environment especially a reflecting wall, the Theoretical Imaging Method is usually used. This method makes it easy to derive analytical formulas of the total and differential cross sections. From these cross sections, we may infer the distance between the source and the wall, properties of the absorbing walls and adsorbate dynamics. Currently a research is going on using this method on parallel and perpendicular walls in

and in the absence of an electric and magnetic fields and then is to compare the results with those of Closed-orbit Theory.

Dr. Afaq Ahmad

(Assistant Professor, Physics, CIIT Lahore)

New Research

Top Physics stories of the year 2008

1. New family of quaternary iron-based compounds superconductors at tens of Kelvin

A research group in Japan reported that fluorine-doped lanthanum oxide iron arsenide is a superconductor at 26 K. The new iron-arsenic materials are the first relatively high-temperature materials that don't contain copper and remain superconducting above a temperature of 50 K. Researchers hope these superconductors might help in manufacture of better quality superconducting wires.

Y. Kamihara, T. Watanabe, M. Hirano, H. Hosono, *J. Am. Chem. Soc.* **130**, 3296 (2008)

2. Large Hadron Collider:

In September 2008, the world's largest scientific instrument Large Hadron Collider (LHC) started operations near Geneva, Switzerland. In this huge particle accelerator, two proton beams traveling at unprecedented high speed (close to speed of light) will be smashed together to produce and study new particles which may be produced as a result. The experiment could not be accomplished successfully

but scientists were succeeded in producing the beams around its circular path of 16 mile circumference. General operations of LHC will resume in the summer 2009.

Source: <http://lhc.web.cern.ch/lhc/>

3. Planets:

New planets orbiting distant stars outside our solar system have been directly imaged by Gemini, Keck and Hubble telescopes.

C. Marois et al., *Science* 322, 1348, (2008)

P Kalas et al., *Science* 322, 1345, (2008)

4. Quarks:

New combinations of the quarks are observed for the first time. Usually nuclear particles consist of up and down quarks. In addition to this there are four other types of quarks. Recently, nuclear particles consisting of bottom quarks were observed. At Fermi lab, in an experiment, a particle containing two strange quarks and one bottom quark was detected. At the KEK lab in Japan, several mesons like particles consisting of four quarks (not the usual two quarks) were detected.

Source: http://ptonline.aip.org/journals/doc/PHTOAD-ft/vol_61/iss_6/18_1.shtml

http://ptonline.aip.org/journals/doc/PHTOAD-ft/vol_61/iss_11/20_1.shtml

5. Ultra Cold molecules

This year first ever accumulation of molecules at a temperature near absolute zero was made possible.

Previously laser was used to slow down particles to near stillness in order to study their properties. But this method is not successful as molecules have complicated internal motions. But now it is made possible to first cool atoms and then allow them to combine at a very low temperature near absolute zero to form molecules. Labs at NIST / Colorado ([Science, 10 October 2008: 202-203](#)) and at the University of Innsbruck ([Phys. Rev. Lett. 101, 133005 \(2008\)](#)) made atoms to pair up atoms into molecules and collect in high densities at very low temperatures inside traps. Also see [Phys. Rev. Lett. 101, 133004 \(2008\)](#)

6. Diamond detectors:

Little Imperfections in diamond are used to study how atoms can behave as tiny magnets. Diamond is made of cross linking of carbon atoms. If one atom is missing from the network; the empty hole in combination with a stray hydrogen atom behaves a strange molecule in the middle of all those carbon atoms. This “molecule lights up and shines when a laser light falls on it so diamonds can be used as high sensitivity detectors.

[Source: /www.aip.org/pnu/2008/split/875-1.html](http://www.aip.org/pnu/2008/split/875-1.html)

7. Light passes through the dark matter:

The Scientists have made possible to make the light behave in a different way. When light strikes an opaque material, a part of it is absorbed in the material and rest of it is scattered. But in an experiment at the University of Twente Netherland major portion of the light is made to get absorbed

in the opaque material if wave front of incoming light is shaped by special filters.

[M. Vellekoop and A. P. Mosk, Phys. Rev. Lett. 101, 120601 \(2008\).](#)

8. Farthest Seeable thing:

Scientists have succeeded in seeing a bright gamma ray light coming from a distance of 7-billion light years in space. The light is referred to as gamma ray burster which was observed by swift satellite specially designed to observe gamma rays.

[Vreeswijk, P. M. et al. GCN Circ. 7444 \(2008\).](#)

Not wonder, this is Physics

The air around us is not weightless. A column of air one inch square and 600 miles high, for instance, weighs approximately 15 pounds, about twice as much as an average newborn baby. This is the weight which creates the phenomenon known as "atmospheric pressure".

News Bulletin

1. The Director CIIT Lahore Dr. Shaukat Ali Hayat hosted a dinner in the honor of the students, parents and the faculty on December 4, 2008 to celebrate student's achievements in the Convocation 2008 of CIIT Lahore.
2. The Convocation 2008 of the CIIT was held at Lahore Campus on December 5, 2008. Dr. S.M Junaid zaidi, Rector CIIT was the chief guest on the occasion. He appreciated the efforts made by the faculty in different disciplines to impart quality education to

students, and emphasized the need to bring new projects.

3. The name of Dr. Muhammad Asif, Assistant Professor, has been published in the Directory of Productive Scientists of Pakistan 2007. http://www.pcst.org.pk/pcst_webpages/RPA%20Ads/RPA%20Ads%202006-07.htm
4. A research paper by Dr. Muhammad Ashfaq Ahmad titled, “Superposition of two coherent states π out of phase with average photon number as relative phase” has been published in journal Optik. 120, 68-73 (2009).
5. A research paper by Dr. Afaq Ahmad titled, “Interferences in Photodetachment of a Negative Molecular Ion Model” has been published in Journal of Commun. Theor. Phys. 50 (6), 1401-1406 (2008).
6. Another research paper by Dr. Afaq Ahmad titled, “A study of FBG sensor and electrical strain gauge for strain measurements” has been published in Journal of Optoelectronics and Advanced Materials 10 (10) 2564-2568 (2008).

Photo Gallery

Some of glimpses of the wonderful moments of the Convocation 2008 are posted below.





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