Sunset Astronomical Society

The Sunset *Gazette*

Serving the Tri-Cities since 1975

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Meeting information

Meetings are generally in the theater in the Delta College Planetarium in Bay City. The meetings will usually be on the 2nd Friday of each month at 7:00 PM. Watch the newsletter for changes in dates and times. Membership is not required to participate in meetings and activities. See last Page for this month's meeting site.

Membership Information

Our club has switched to e-mailing our newsletters. For those wishing to receive a hard copy mailed an additional dues of $10.00 per year is required.

New Membership Rates:

5$ per Year

Treasurer's address for renewals and subscriptions:

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Cosmic Rays

In search of a new series for the SAS newsletter I came across an astronomical anniversary which happened last year but probably never made it into prime time news: The 2012 100 year anniversary of the discovery of **cosmic rays**. During a high altitude balloon experiment the Austrian physicist Victor Hess discovered that the ionization of the atmosphere increases in ever greater altitudes and inadvertently opened a new window to observe the universe, a window which involves the most highly energetic processes known in the cosmos which even today are not yet fully understood.

Of course no scientific discovery comes completely out of the blue and the history of the cosmic rays can be traced way back to Charles August Coulomb, a French physicist (1736 – 1806) best known for his research about the electrostatic force of attraction and repulsion known as Coulomb's law. In his experiments in 1785 he noticed that no matter how carefully he insulated his electrically charged metal spheres they always lost their electrical charge in air over time. Little did he know that this effect actually had a cosmic origin in form of charged secondary particles generated by cosmic rays. 50 years later Michael Faraday (1791 – 1867, an English experimental scientist whose main contribution was on the fields of electromagnetism and electrochemistry with discoveries like electromagnetic induction, diamagnetism and electrolysis) was able to confirm the discharge effect in further experiments where he used even better insulation. His fellow countrymen William Crookes, a chemist and physicist, discovered in 1879 that the ionized air itself was responsible for the discharge effect and by reducing the air pressure further and further he was able to show that at one millionth of the atmospheric pressure the discharge finally became negligible. At the end of the 19th century a range of discoveries led to a much better understanding of the ionization of air: In 1895 Wilhelm Conrad Roentgen discovered the X-rays capable of penetrating solid matter, only one year latter Antoine Henry Becquerel discovered radioactivity and in 1897 Joseph John Thompson the electron. And in 1900 Paul Ulrich Villard found the gamma rays, an electrical neutral and the most penetrating component of radioactive radiation. The electromagnetic nature of the gamma rays was only discovered fourteen years latter by Ernest Rutherford and Edward Andrade due to its diffraction at crystals.

All these results and discoveries led scientist believe that the ionization of the air was caused by radioactivity stemming from the earth's crust itself where all theses new radioactive elements like uranium, radium or polonium were found. Therefore the ionization of the air should be diminished in higher altitudes due to the absorption of the radiation by an increasing layer of air. But something did not add up: Measurements over large and deep bodies of

water should have led to a distinctive reduction of the rate of electrical discharge but the reduction was much smaller than anticipated. A similar pictured emerged when the first measurements were taken in respect to the altitude. In 1910 the air ionization and discharge rate was measured by the Jesuit Theodor Wulf on the Eiffel tower. For that he developed an electrometer, which could measure the rate of ion production inside a hermetically sealed container. He found that according to his results either a second source for gamma radiation was necessary or that the absorption of gamma rays by the air was significantly less than believed. A key experiment was carried out by Domenico Pacini (left picture, courtesy Wikipedia) in the Summer of 1911. He found that in 3 m (10 feet) of water the radiation was decreased by about 20% which could be caused only by absorption in the water layer above. This was a strong hint regarding the extraterrestrial source of the radiation but unfortunately the experiment received very little attention.

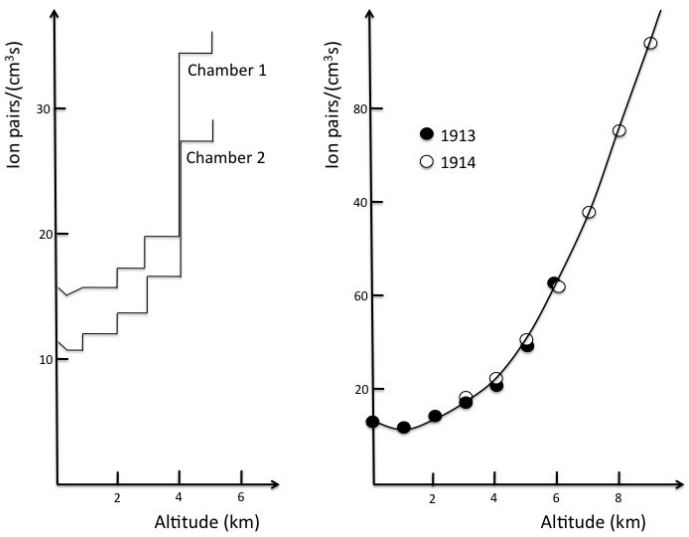
This problem of the less then expected decrease of ionization with increasing altitude came to the attention of Victor Franz Hess, first assistant at the new Institute for Radium Research in Vienna, Austria. In his opinion only two possibilities remained to explain the results: either the absorption of gamma rays is lower than expected or a yet unidentified ionizing agent is acting in the atmosphere. To confirm the former he measured the absorption coefficient of radium gamma rays in air: his measurements confirmed the previous results and ca 500 m above ground all gamma rays generated by the earth's crust should be absorbed. Having excluded a lower than expected absorption of gamma rays in the air he prepared for 7 balloon experiments to investigate the ionization of air in dependence of the altitude.

Hess lands after his balloon flight in 1912 . Source Wikipedia.

The breakthrough measurements were achieved with the last balloon experiment were they reached 5350 m (17540 feet) and the crew was barely able to properly read the last of the three Wulf electrometers. But the experiment was successful: at 1000 m above ground they measured a small decrease of ionization but at 2000 m the value increased to be similar to ground levels, at 4000 m the value increased by 50% and then to 100% at 5000 m. Hess explained he observations that a highly penetrable radiation must enter the Earth atmosphere from above which is able to ionize air even in the lower regions. He also ruled out the Sun as the origin of the gamma radiation because its strength was independent from night or day time. Further balloon experiments with improved electrometers by the physicist Werner Kolhörster in 1913 and 1914 confirmed the observations. In 9300 m (30500 feet) he found a six times higher ionization rate compared to ground levels and

deduced that the new radiation had an absorption length of at least 1300 m, a full order of magnitude higher than all known sources of gamma radiation.

It was Robert Millikan who created the name '**cosmic rays'** and he believed that the primary cosmic rays were gamma rays = very energetic photons and therefore neutral and free of charge. His theory was that they would be produced as by-product of the fusion of hydrogen into helium and heavier elements. The secondary electrons in the atmosphere would be produced by the so called Compton scattering of the primary gamma rays. Compton scattering is the inelastic scattering of a photon by a free charged particle, usually an electron. But this was not the whole story: In 1927 the Dutch scientist Jacob Clay identified a new effect with the help of a transportable ionization chamber which he carried on his travels between the Netherlands and Java. He observed that the 'cosmic rays' changed with the geographic latitude and he deduced that apparently the Earth magnetic field had some sort of role to play and that at least some part of the cosmic rays were not photons but charged particles which hit Earth from all directions. It was again Kolhörster together with Walther Bothe who identified the cosmic rays as high-energy charged particles by using the recently invented Geiger-Muller counter which allowed the measurement of single ionization events. It was known that gamma rays generated only low-energy charged particles when passing through matter. Those charged particles would be detectable with the Geiger-Muller counter. By placing two Geiger-Muller counters on top of each other separated by an absorbing material the charged particles generated by a gamma ray should be absorbed in the material between the two counters and not be measurable in the lower counter. But they found no decrease of the event and discovered that the cosmic rays were able to penetrate the absorbing material, a 4.1 cm thick gold layer. It became clear that gamma rays which till then were connected with nuclear processes simply lack the energy seen in these events and they postulated that charged particles aka cosmic rays could be accelerated by weak but immensely vast electromagnetic fields outside of our galaxy. With this they came already quite close to the idea of cosmic particle generators.



Increase of ionization with altitude as measured by Hess in 1912 (left) and by Kolhörster (right). Source Wikipedia.

In the next years the research into cosmic rays became the foundation of the particle and high-energy physics and the Earth atmosphere its laboratory due to the fact that in these days no particle accelerator was anywhere sufficient enough to conduct high-energy physics. In 1930, the Italian physicist Bruno Rossi predicted that the charge of these particles could actually be determined from a difference between the intensities of cosmic rays arriving from the east and west. Measurements proved that most primary particles are positive and consists mostly of protons whereas the secondary radiation produced in the atmosphere consists primarily of electrons, photons and muons. Later in 1948 observations carried out with balloons showed that approximately 10% of the primary particles are helium nuclei (alpha particles with a charge of +2) and 1% are heavier nuclei of the elements such as carbon, iron and lead.

In the next SAS newsletters: New detection methods, an avalanche of new elemental particles, higher and higher energies, detection of cosmic rays and what processes do actually generate cosmic rays.

SUNSET ASTRONOMICAL SOCIETY
THE SUNSET GAZETTE
SERVING THE TRI- CITIES SINCE 1975

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This issue can be accessed in color on the website of the SAS!!!

http://www.sunsetastronomicalsociety.com

SAS Meeting

Start: 7:00 PM

Friday, Nov 8th, 2013

Delta Planetarium

Welcome members and guests

New and old business

Club Business

Treasure report

Refreshments Break

Presentation:

TBD

If clear we will observe on the observation deck.

What's up in the Sky

Nov 2-15 *Dawn*: Look out for the zodiacal light in the east 120 to 80 min before sunrise. Dark location needed. The zodiacal light looks like a tall, broad pyramid of light with Mars near its apex.

Nov 3: Daylight Saving time ends

Nov 3: New Moon

Nov 6 *Dusk*: Watch out for Venus 7 deg to the lower left of the waxing Moon.

Nov 10: First Quarter Moon

Nov 11-28 *Dawn*: Good time to spot Mercury well above the east-southeastern horizon ca 45 min before sunrise.

Nov 17: Full Moon

Nov 17,18 *Dawn*: **Comet Ison** close to Spica - maybe visible to the naked eye. Binoculars recommended!.

Evening: The Moon shines right of Aldebaran and the Pleiades on 17th and left of Aldebaran on 18th.

Nov 25,26 *Dawn*: Saturn can be found less than 1 deg from much brighter Mercury. **Comet Ison** may be visible far below them 1/2 hour before sunrise.

Nov 25: Last Quarter Moon

Nov 29 *Dawn*: Look out for Spica to the lower left of the waning crescent Moon. The Moon will occult Spica during daylight in North America, but Go-To Telescope maybe needed for better location because the crescent will be very difficult to locate.

UPCOMING EVENTS