# CASPER 2009 RET (Research Experience for Teachers) at Baylor University, Waco, Texas

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## Abstract

The 2009 RET Program at Baylor University has been exactly as advertised. It has been a diverse experience both in a functioning Dusty Plasma Lab but also lectures on assorted cutting edge topics and discussions with fellow physics instructors ranging from programs of study to curriculum implementation. Exploration of four and seven particle chains, height measures of particle clouds, Vere laser use and time dependent dispersion of particle clouds were experiments studied during the institute.

## Introduction

The Research Experience for Teachers at Baylor University affords an excellent opportunity to further educational background and to participate in a positive learning experience.

Last year's experience in the high velocity-impact division of the CASPER lab afforded background that was incorporated into lessons this past school year. Looking to again gain background knowledge and the possibility of returning to work in either the high impact lab or the # 2 GEC plasma cell group was the motivation to reapply to this year's program.

## 1. The Research Segment of the Program

*1.1 Choice of the Experimental Plasma Group.*

The initial project discussion involved researching properties of Moon Dust and using the Impact lab to collect basic data. Due to vacation times of the support staff and wait time for delivery of materials, this project was put off till the fall semester. The Dusty Plasma researchers at the CASPER lab on the Texas State Technical College were in need of support work with processing data on seven and four vertical particle chain oscillations. This particular need and the possible chance to observe ongoing work using the new Vere laser helped make this year's final work choice.

*1.2 Participation during the institute*

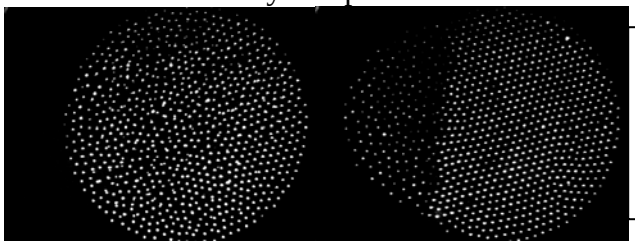
Discussions with Lab Director Jorge Carmona-Reyes and Dr. Jie Kong were helpful to gain knowledge about the Matlab, Labview and Image J software programs. The investigation of side view pictures of seven (melamine formaldehyde, mf) particle vertical chains included making sure that the software detected all seven particles. Each data set included 600 individual pictures and each one had to be examined.

The second project involved collecting pictures of mf four particle vertical chains in the GEC cell #2 and repeating the examination process used for seven particle chains. In addition analysis software was run to find and compare the frequency of oscillation and amplitude for each particle. The goal of these investigations is to find the ion drag forces on the particles and how each particle's oscillation influences the other particles.

The third project was to take measures of gold and mf particle cloud heights at different powers and pressures. Powers of one to fifteen watts were used with jumps of one watt. Pressures of one hundred to four hundred millitorr were tested at each power. Nine pictures were taken of each mf test set and one hundred and twenty pictures were taken for the gold dust cloud set. Average height measures were made of each picture and then the set average. An average height per set was used to make a graph of the data vs. power. Presently there is a match between gold and mf at one hundred millitorr. More data at other pressures needs to be taken to complete the experiment.

The final project during the institute was under the direction of Jorge Carmon-Reyes. A 50-50 mix of gold dust and M Formaldehyde was examined at different pressures and powers to measure the separation between the vertical plane height of each type of dust.

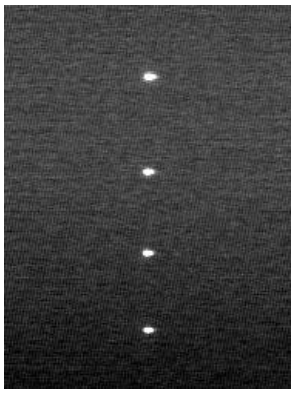
An aside from this investigation showed a laser effect on one type of particle. After 30 minutes at powers less than 3 watts the particles would form in separate clouds. When the laser was turned off the clouds would mix similar to the original drop. At three watts or higher the mix remained in one cloud. More research is needed to pin down the actual power when the two clouds form and why this phenomena occurs.

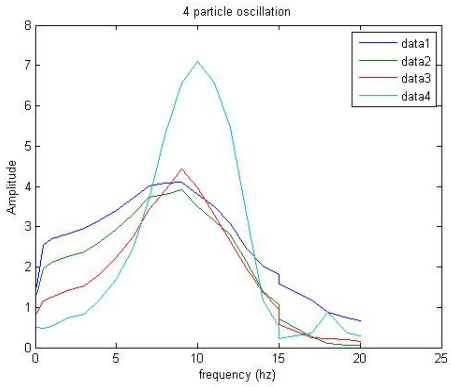


Dust cloud mix of 50-50 mf and gold. Left figure shows the cloud at the initial drop and the second show the separation after thirty minutes.

*1.3 Computer Picture Sample*

The following picture is a sample from the experiment of a four particle chain created by using a glass box on the lower electrode of GEC cell #2.






The picture on the left shows a 4 particle vertical mf chain. The graph shows the frequency vs. amplitude of each particle.

*1.4 Results*

The seven particle experiment graphic results are presently inconclusive and are being reexamined by Dr. Kong. More data needs to be collected to verify the first run. The present models are showing a spike at low frequencies for highest amplitudes.

The four particle experiment shows definite common frequency around ten hertz where each of the particles has a maximum oscillation amplitude. Quadratic models by Dr. Kong have been fit to each of the particle's motions.

Cloud heights of gold and mf seem to match at all powers used when the pressure is 100 millitorr. A nature log model was fit by Jorge Carmona-Reyes. More data needs to be taken to reproduce and verify the findings. Also why these different types of materials act similarly needs to be explained. At the pressure of two hundred millitorr the cloud heights differ slightly with the mf splitting into two clouds. At three hundred and four hundred millitorr the data is insufficient at this time to make conclusions.

Time dependence of fifty-fifty mix of gold and mf show a separation of materials when working at powers below three watts after thirty minutes. There seems to be some relationship between the use of leaving a viewing laser fan directed on the cloud and when it is not turned on. Initial pictures show that the materials mix when the laser if turned off and then reseparate the instant the laser fan is turned on. A explanation of the initial separation, the power settings when the separation occurs, if the laser fan is causing the separation, why the separation seems instantaneous after the initial separation, are all questions that have been ask and will need further investigation.

## 2. Lectures, Discussion Sessions and Field trip.

*2.* 1 *Lecture sessions*

Each Wednesday members of the summer institute gathered at the Baylor University Science Building for a luncheon and lecture based on the expertise of invited Baylor staff members. Talks included String Theory fundamentals, CERN and LHC updates and related topics about the cosmos.

*2.2 "Gear Up" meetings*

Each Tuesday morning the teachers in the program were scheduled to meet for discussions and presentations by "Gear Up" director Cindy Hernandez. "Gear Up", a Baylor University outreach program in cooperation with the Waco Public schools presents science programs (Physics Circus, etc.), summer institutes for students and teachers with follow up studies of student progress through graduation.

*2.3 Field trip to Lockheed- Martin*

A field trip to the Lockheed –Martin assembly and research site in Fort Worth, Texas was offered to both REU and RET members of the institute. The outing was a one day excursion with tours of the assembly line for F-22 fighter jets, optics lab and materials lab along with lectures by senior engineers. Presented was the fact that the average age of the staff in the corporation is middle 50's. Emphasized was the fact that college grads in physics and engineering were welcomed to apply for employment.

## 3. Conclusion

More programs of this type need to be offered and more participants need to take part to renew classroom enthusiasm for science and increase instructor background knowledge. This type of program can not only be an inspiration to participant's students to pursue careers in science but also a means to educate the general public to the need for funding future science research.

Valuable experience has been gained of how a working lab operates. The opportunity to see the interactions of the personnel, communication between the lab technicians and experimental investigators, team work of carrying out experiments has been an enlightening experience.

**Acknowledgements**

Many thanks are needed for this opportunity to participate in the CASPER 2009 Research Experience for Teachers funded by the National Science Foundation. Dr. Truell Hyde and Dr. Lorin Matthews are to be commended for their foresight and dedication to providing this program. Jorge Carmona-Reyes and Dr. Jie Kong, experiment investigators, have patiently answered questions and found meaningful task in support the institute. Mike Cook and Jim Schmoke have been helpful in discussing lab issues and questions relating to the GEC cell.

Thanks must go to Cindy Hernandez for her presentation and discussion sessions about the "Gear Up" program.

## My Internet Resources for Plasma

Sandia National Labs
http://www.sandia.gov/bus-ops/partnerships/tech-access/facilities/pmtf.html
Plasma Physics and Controlled fusion
http://www.iop.org/EJ/journal/PPCF
Plasma on the Internet
http://plasma-gate.weizmann.ac.il/PlasmaI.html
Coalition for Plasma Science
http://www.plasmacoalition.org/
A Teacher's Guide to Plasma Science on the Web
http://www.plasmacoalition.org/edu.htm
Free Software for Atomic and Plasma Physics
http://plasma-gate.weizmann.ac.il/FSfAPP.html
Plasma Physics Reports
http://scitation.aip.org/ppr/?jsessionid=2543571091194670271
Coulomb Crystals in Plasma Processing Reactors
http://uigelz.ece.uiuc.edu/Projects/DTS/dts.html
Space Science Education resource directory
http://teachspacescience.org/cgi-bin/search.plex?mode=new&newgr=9,10,11,12
RPI Plasma Dynamics Laboratory
http://hibp.ecse.rpi.edu/
Plasma Dictionary
http://plasmadictionary.llnl.gov/
Laser Diagnostics of Plasma
http://wwwrsphysse.anu.edu.au/prl/laser_diag.html
Dusty Plasma Physics… Imperial College London
http://www.pp.ph.ic.ac.uk/dustpage/
The internet Plasma Physics Education Experience
http://ippex.pppl.gov/
Theoretical Principles of Plasma Physics and Atomic Physics… very high end
http://www.plasmaphysics.org.uk/
Plasmas – the Fourth State of Matter…nice source of pictures and intro materials
http://fusedweb.pppl.gov/CPEP/Chart_Pages/5.Plasma4StateMatter.html
Auburn University Plasma Science Laboratory --- nice source for DC plasma study
http://narn.physics.auburn.edu/