Mid Internship Report

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NASA Ames Research Center

International Internship Programme I^2

Dear reader,

I arrived at NASA Ames in Mountain View, California on the 4th June 2019 to undertake a 10 week internship as one of approximately 120 interns here for the summer. And out of those 120 interns, there are five of us from Trinidad and Tobago. I find it absolutely amazing that this initiative exists for TT nationals and can only hope that the opportunity continues to be offered for many year to come.

Let me give a brief introduction of myself. I grew up in Trinidad in the early 90's and received all my education there until the end of secondary school. Then I ventured to the UK to undertake a Natural Science MSci degree at the University of Leicester. Currently, I'm in my 3rd year PhD at the University of Oxford, researching hybrid boron nitride and carbon nanotubes. These nanotubes are really, really tiny cylinders that have gripped the scientific community for a little over 2 decades now. I am interested in the hybridization of boron nitride and carbon to see the effect on nanotube thermal and electrical properties, in the hope that they can be applied as thermal management materials for electronics.

It was exciting to discover that one of the projects offered for this internship was titled 'nanomaterials for sensors and electronics'. This sounded just the right fit for me, as I wanted to gain more perspective on the manufacturing of actual devices from nanomaterials. So, I applied and here I am writing this report for you on a Thursday evening from my room at the NASA Exchange Lodge. That's my little backstory on how I've ended up interning at the Center for Nanotechnology at NASA Ames. There is another funny story on what motivated me to search for internships this summer, but I won't let you have all the laughs right now. Maybe I'll save that for my final report.

I'll share some more here on the progress of the research project and the overall Ames experience thus far, i.e. mid-way through the internship.

Thank you for reading my report and I hope you can enjoy it as much as I am enjoying being here.

Yours Truly,

Ruth

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Welcome to NASA Ames!

NASA Ames Research Center (ARC) is one of the 10 NASA field centers and dare I say with bias, the best. It is situated in Silicon Valley, a stone's throw away from the tech giants like Google. A lot of research here is open access oriented and the work environment is especially easy going, making orientation an entirely stress-free experience. Safety in the lab is a top priority here and I was very impressed with the safety education all interns were provided.

This internship cohort is quite big compared to some of the other NASA centers, with majority US students. But the international interns are very welcomed. I've met interns from Australia, New Zealand and Portugal, and a few of them are staying around for 6 months!

Meeting other interns during the first week. Here we are pictured at **Megabites**, an onsite cafeteria I frequent for lunch. The salad bar is great.

My office is here----------→

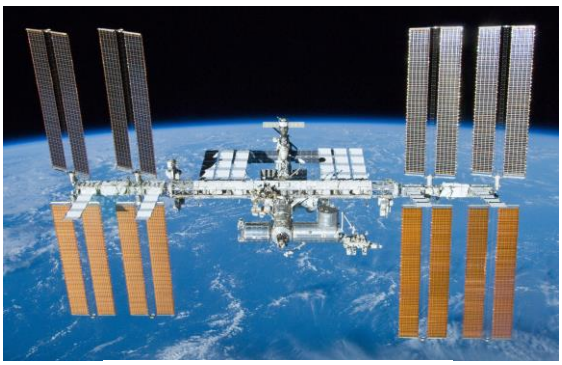
The Center for Nanotechnology and Mars Exploration. It is about 5 minutes walk to my accommodation.

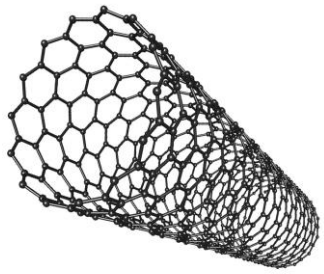
Research Project **Introduction and Progress**

Gas detection on the International Space Station (ISS) is a key part of the routine safety monitoring of crew members. Carbon Dioxide (CO_2) and Ammonia (NH_3) are gases that upon accumulation to their respective threshold concentration within the cabin, can cause discomfort and health hazards to the crew. CO_2 can originate as a metabolic product whilst NH_3 has the risk of leaking into the cabin from the external cooling systems. Thus, gas sensors within the ISS crew cabin must have high sensitivity to these gases. Besides this requisite, such sensors should be economical with regards to energy consumption as well as be low in volume and weight. Current sensors do not fulfil all these criteria. Furthermore, with the prospect of *in-situ* device manufacturing on the ISS, gas sensors that are possible to produce via additive manufacturing can one day be printed and replaced onboard.

Chemiresistors with carbon nanotubes (CNT) as the active sensor element have been proposed as efficient gas sensors. This is because they offer an immense surface area for adsorption of gas molecules, which then alter the CNT electronic structure. This change can then be observed as a change in the sensor resistance. Such a sensor has been developed at the Center for Nanotechnology at NASA ARC with single-walled CNTs functionalized by carboxylate groups (SWCNT-COOH) . This sensor is capable of detecting both CO_2 and NH_3, and can do so at 62% relative humidity, which is the level of humidity measured on the ISS. Moreover, this sensor offers the advantage of simple fabrication via the deposition of SWCNT-COOH onto electrodes on a printed circuit board substrate.

My primary mentor Dr Beomseok Kim has already been successful at fabricating a functional SWCNT sensor. My task has been to understand the sensor detection mechanism.





Top. Image of the International Space Station. Bottom. Illustration of a single walled carbon nanotube used in the gas sensor.

This has involved computational modelling via python to simulate changes in the sensor chemical environment when the SWCNT is exposed to the target gases. As a deliverable, I am assisting in the writing of a scientific article for publication.

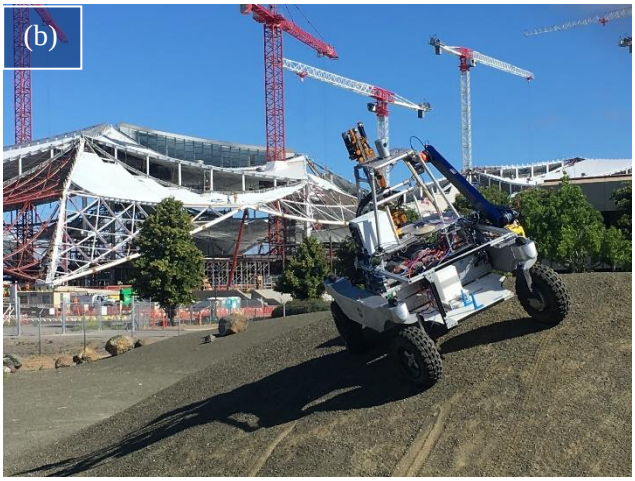
Given that I have had previous experience using python for coding but do not use it regularly for my current PhD, this project is really building on my coding skills. It is eye-opening to see the interdisciplinarity needed to make and understand a functional nanomaterial-based device; there's material science, chemistry, electronics design, coding etc. This experience at NASA is certainly taking me out of my comfort zone of merely nanomaterial synthesis and has made be more aware of both the possibilities and challenges ahead for transferring laboratory nanomaterials research to real world applications. Teams such as the group headed by Dr Meyya Meyyappan at NASA are making progress on this front in the realm of sensor technology.

Tours and Lectures at NASA Ames

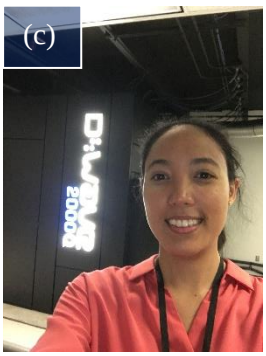
Dr James Green giving his lecture on 'The Future of Lunar Exploration: Artemis Project'.

The annual Summer Series of expert seminars held at the Syvertson Auditorium runs from June 11th to August 14th, which roughly coincides with the summer internship period. Everyone at Ames is welcome to attend. This year, the series kicked off with a talk by Dr James Green, NASA's Planetary Science Division director. He passionately highlighted the story of our Moon, explaining theories on formation and NASA's research into lunar material properties. This is all leading up to the Artemis Project, for the first woman and next man to walk on the moon. I also attended the talk given by Dr Moriba Jah, who heads his own group at the University of Texas at Austin as a world expert in space object monitoring. His talk was very enlightening about the challenge of space traffic monitoring, an issue that will become more and more a priority as the number of objects orbiting the earth will increase as we progress into the space era. I am looking forward to more talks, particularly two upcoming ones this month!

Interns are also invited on guided tours of Ames facilities so that we get to know more about the research going on at Ames outside of our research groups. I've been on four tours- the Mars Roverscape, the Vertical Gun Range, the Supercomputing facility and the Fluid Mechanics Lab.



(a) At the **Vertical Gun Range**, where they simulate high velocity impacts on the small scale. The 'gun' here is in horizontal position but can be tilted at an angle to the impact chamber.



(d) At the **Fluid Mechanics Lab**. Pictured is a visualisation of air flow patterns around a miniature space shuttle.

(b) Rover design in R&D seen here at the **Mars Roverscape,** a plot of terrain that mimics some of the topographical features on the surface of Mars.

(c) Visiting the Ames **Supercomputing facility**. Pictured behind me is a Quantum computer operated in collaboration with Google and USRA.

Living at the NASA Exchange Lodge

The Exchange lodge houses most of the NASA summer interns, with few living off-site. I share a room, in American college style, with my roommate, Samantha. The environment is incredibly friendly, and the other interns are all approachable and willing to talk about their background and research interests. In just a few weeks, friendships have blossomed, and I hope to stay in touch with many of these inspiring people. Somewhere that I meet new people all the time is the communal kitchen. It's great to cook there, learn new dishes from other interns and sometimes teach cooking skills to the less experienced 😉.

The NASA Exchange Lodge.

I've played my first ever game of Dungeons and Dragons and sang impromptu karaoke 'Colours of the Wind' by the laundry room. All in all, a wonderful experience so far.

(a) There is a pool on campus! Great for a relaxing swim after work. **(b)** Getting in a game of Bananagrams in the Block B kitchen.

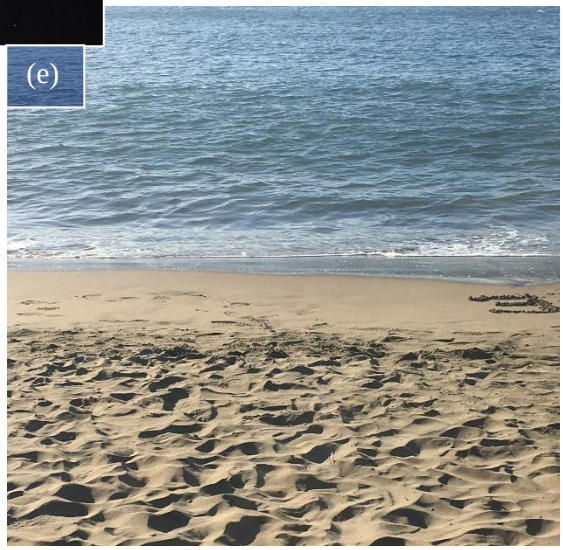
(c) Celebrating our fellow intern Rahat's Birthday in the Lodge Block B kitchen. This was a carefully coordinated surprise that involved a blindfolded trip in a car to a restaurant and a rich chocolate cake to end the night.

California !

This is my first time on the west coast of North America. I have friends who dream of living here after they graduate but I never understood the craze. But now I do understand it more; the weather is fantastic and there is a lot going on. I've been on several trips to San Francisco to see the Golden Gate bridge and to explore the city. I also went on my first ever hike at Muir Woods, which has some phenomenal towering redwood trees.

Weekends are also culinary exploration time, and Castro street in Mountain View is a buzzing street with so many food options on offer.

Another highlight for me has been the recent 4th of July celebration- a group of us travelled to San Jose to witness a world-class fireworks display hosted by the Rotary Club.



(a) Interns on a culinary adventure- trying out Mexican food. (b) San Francisco Golden gate bridge. Brian kindly offered to drive us there. (c) Muir Woods' gigantic redwood trees. (d) 4th July Fireworks in San Jose.(e) San Francisco Aquatic Park Cove.