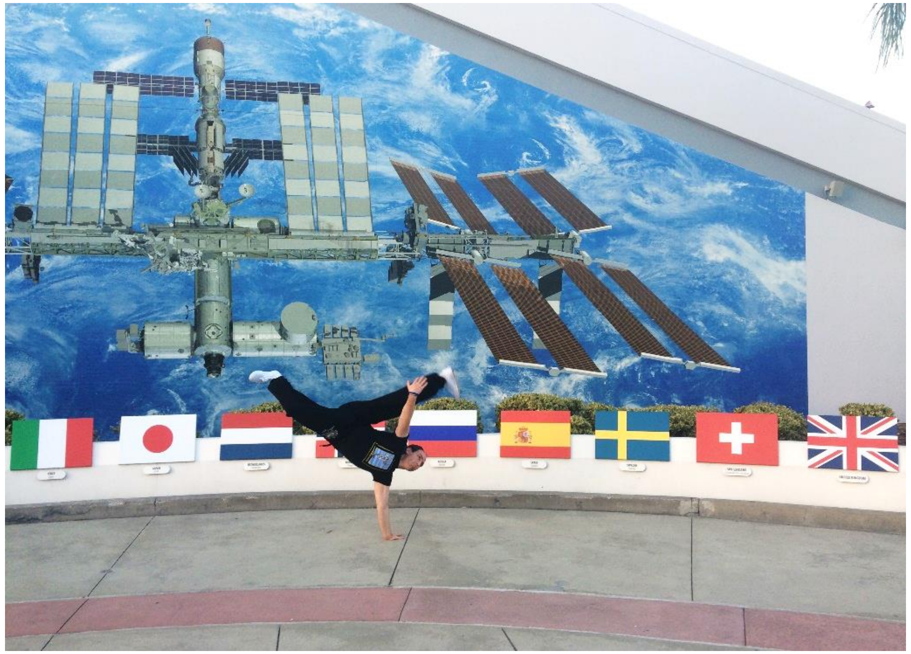
Midwest Region "Space Grant Short Talks"

Helping students fly high: how to teach physics (and a whole lot more) using high-power rockets

Tonnis ter Veldhuis
Macalester College



Analysis of RNAseq and Root System Architecture of Arabidopsis Grown on the International Space Station

Richard Barker
U of WI - Madison

"Astronaut Training" with Rideable Hoverboards: An Educational & Memorable Activity For All Ages

James Flaten
U of MN – Twin Cities

Friday, April 19, 2019. 1 to 2 p.m. Central Time. Link to join the Zoom videocon: https://umn.zoom.us/j/7261550823

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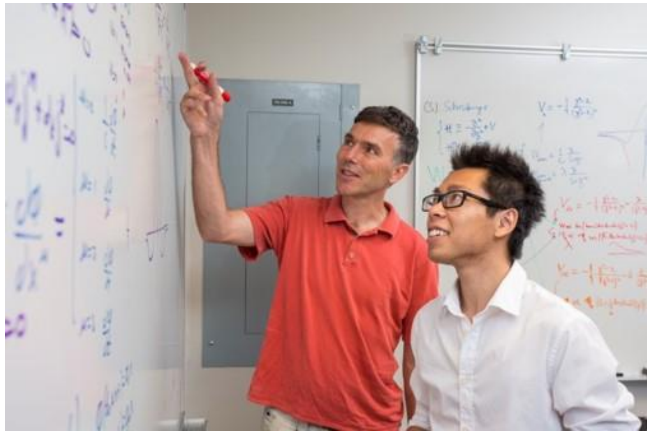

Tonnis ter Veldhuis is a theoretical physicist at Macalester College. His research interests include beyond the Standard Model phenomenology, cosmology, and formal aspects of quantum field theory. His course offerings include special topics courses in elementary particle physics and general relativity. He is also the advisor of the Macalester high power rocketry team.

Helping students fly high: how to teach physics (and a whole lot more) using high power rockets

All incoming students at Macalester take a first-year course during their first semester on campus. The goals for first-year courses are many and diverse; create a sense of community and belonging, familiarize students with campus resources, train them in college level writing, and, in my department, provide them with solid calculus-based introductory physics instruction, preferably with a practical component. Instructors of first-year courses also serve as academic advisor for students in their class, which typically consists of about 16 students, and they function as a primary contact in case students face personal issues. Given all the demands, first-year courses are not easy to teach, and my previous, more traditional offering had met with mixed results.

So, in fall 2018 semester I tried something completely different. Inspired by the enthusiasm and success of students participating in the newly formed Macalester rocketry team, and with invaluable support from Dr. James Flaten and the Minnesota Space Grant Consortium, I created a new first-year course called “Rocket Science.” In this course students learn mechanics in the context of rocketry and space sciences. Homework assignments and exam questions are based on real applications in these fields. Instead of a traditional lab, students work in groups of four to build and launch high power rockets. In the process, they learn how to collaborate as a team, how to plan and schedule a complex project, how to test and integrate individual components, how to adequately document progress, how to use a variety of tools, how to use simulation software, how to acquire and analyze sensor data, and how to effectively communicate results. The writing component of the course is delivered with a scaffolded structure, consisting of five writing assignments of increasing complexity, culminating in a final research paper with a topic centered around the theme “Crewed mission to Mars” in this initial iteration of the course.

End of semester course evaluations showed very positive responses from students. Exam and homework results indicated that students learned the required physics. Students in the class coalesced into a positive group and formed bonds that likely will last through their Macalester careers and beyond. In this talk I will discuss why the course worked so well, and how its success might be replicated at other institutions.

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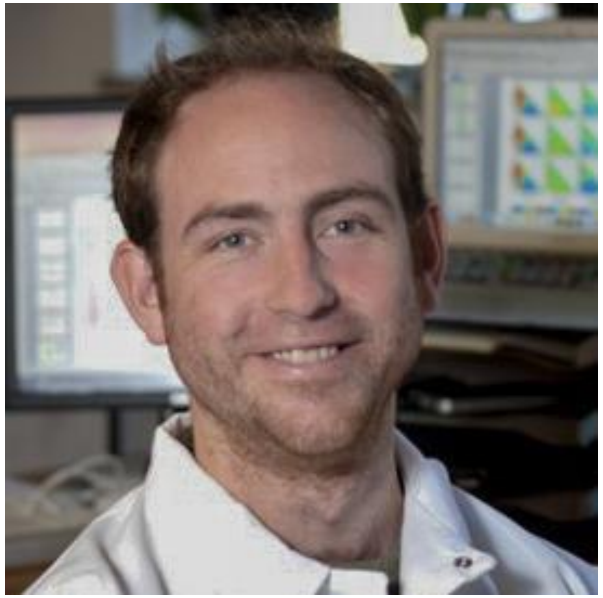

A brief description of Richard Barker's work history and biography

It has been nearly a decade since Richard Barker completed his Ph.D. research project on the "Genes of the Green Revolution." This experience cemented a fascination about the sensitivity of plants roots to their environment that would see him move to a "New World" in search of new methods to address this phenomenon. This passion for science led him to become the Co-Chair of the NASA plant advanced working group as part of the NASA GeneLab project. He studies new methods to visualize NASA life science genomic data. As an early stage researcher, he is always looking to expand his network of collaborators to make the most of the Gene Lab data repository. In addition to bioinformatics work, he has had the opportunity to do some experimental work on the International Space Station (ISS). The "Gilroy TOAST3" / NASA APEX-05 experiment recently conducted on the ISS provided invaluable feedback on analysis, interpretation, and data sharing.

Example abstract to demonstrate research interest.

Title: Analysis of RNAseq and Root System Architecture of Arabidopsis Grown on the International Space Station

Authors: Richard Barker, Arkadipta Bakshi,Won-Gyu Choi, Sarah Swanson, and Simon Gilroy

Abstract: In December 2017 we conducted the APEX-05 experiment on the International Space Station. Arabidopsis seedlings of wild-type (Col-0) and mutants in the Ca2+ transporter CAX2 and the ROS producing NADPH oxidase RBOHD were grown on orbit for 8 days under blue/red LED illumination in the VEGGIE growth hardware. Astronaut Scott Tingle carefully photographed the plants from germination to 8-days old. Kinematic analysis of the development of the root system architecture revealed an important role for ROS production and Ca movement during plant adaptation to novel aspects of the spaceflight environment.

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James Flaten is the Associate Director of NASA's Minnesota Space Grant Consortium. Though housed in the Aerospace Engineering and Mechanics (AEM) department, his academic background is actually in experimental low-temperature physics so he has taught many physics and astronomy classes, in addition to basic engineering. He particularly enjoys using both high-power rocketry and stratospheric ballooning as low-cost means of giving students hands-on experience building and flying aerospace hardware.

"Astronaut Training" with Rideable Hoverboards: An Educational & Memorable Activity For All Ages

A ridable hoverboard is a circular wooden platform levitated using an air blower inflating a skirt on which one more more people can ride over smooth flooring (hardwood or linoleum work best) with essentially no friction. Hoverboards can be purchased from educational vendors such as Pasco, or home-built (much less expensive). They allow the addition of a kinesthetic component to the teaching of many physics and engineering lessons, such as Newton's Laws of Motion, for a wide range of ages. I have used hoverboards in college physics classes down through elementary school settings. They are always a popular draw in informal education settings as well.

One nice connection between hoverboards and NASA is the fact that astronauts use hovercraft to prepare for outer space missions. Astronauts orbiting the Earth are in continuous free-fall, as is their spacecraft. Thus they "float" around with no need for support from nearby surfaces, such as the floor or the walls, and hence don't experience standard friction. Astronauts need to learn to live and work in this friction-free environment. Hoverboards can help people learn what to expect, and practice controlling their motion, in the absence of friction. This aspect of "astronaut training" with hoverboards is far more accessible than free-fall parabolic flights in aircraft and/or neutral buoyancy training underwater. And an "astronaut training" activity sounds much more exciting to students than merely "studying Newton's Laws."

A "Hovercraft Astronaut" role-playing lesson is both engaging and memorable! In additional to kinesthetically experiencing friction-free motion on hoverboard, participants can learn to use a spinning bicycle wheel gyroscope to be able to steer (attitude control) and use a modified CO_2 fire extinguisher as a "rocket thruster" and much more!