THE QUARK

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Upstream Contamination

By George Collier

Imagine you are pouring water from a small cup into another small container filled with powdered chalk, you can imagine that this would be an uneventful process, water will flow from your container into the basin, and you will be left with a mixture of water and chalk at the bottom, but then you notice something: theres chalk in your cup. This is the phenomenon of upstream contamination.

Admittedly the implications of this counterintuitive process are not far reaching. It could have some influence on industrial processes and might perhaps require slight changes to current good practice guidelines in certain fields. Nonetheless, it is worth investigating why this is even possible, and how this can happen.

To begin with, this process is not fully understood, its unknown how the dynamics of swirling flows influences the travel of particles upstream as they travel into the higher container. Despite this there is some research that allows us to better understand the root cause of this process. Originally, it was believed that temperature gradients played a role in the ability of a contaminant to flow upstream, since this phenomenon was first noticed when a physics student at the University of Havana first noticed this phenomenon when he poured hot water into his cup of mate (a caffeinated tea-like beverage) and noticed that some of the leaves from his cup had seemingly traveled upstream into his cup of hot water. At first glance it seems as if temperature gradeints would play a role in this phenomena but further experimentation showed that a temperature gradient was not needed to produce this effect. Not only was it shown that upstream contamination could

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About The Quark

The Quark is a monthly newsletter produced by the Public Relations Committee of the Texas Tech chapter of the Society of Physics Students (SPS). Our goal is to help new students become more familiar with the Physics Department and provide returning students more insight on aspects of the department they might not have been aware about.

If you have any questions about The Quark or SPS, you can email our Public Relations Officer George Collier at george.collier@ttu.edu .

occur in the absence of a temperature differential, but it was later shown to occur with powdered chalk as described above.

It appears that the most important factor in upstream contamination is surface tension. This was initially suggested by the fact that mate and chalk (two materials that are known to flow upstream) both lower the surface tension of water and that when an industrial surfactant was added to the water in the upper container, the flow of particles upstream would stop. It appears that upstream contamination is mediated through the Marangoni effect. What's that you ask? Well, if you have ever looked at a glass of wine then you have probably observed this process. The Marangoni effect is the transfer of mass across two fluids due to a surface tension gradient. Surface tension describes the tendency of fluids to maintain a minimal possible surface area, high surface area indicated that the fluid is highly resistant to external forces due to the high cohesion of its constituent molecules. This means that any liquid with a high surface tension will naturally pull more on surrounding liquids than fluids with lower surface tensions as the molecules of the fluid try to minimize their surface area.

The surface tension gradient created by evaporating ethanol causes the "tears of wine" phenomena.

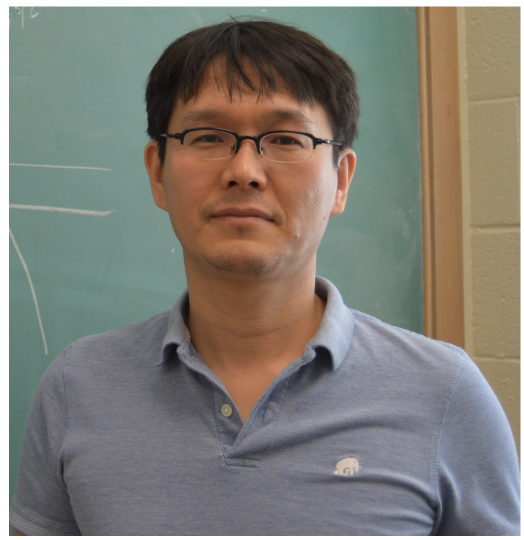
You may have noticed that a thin ring of fluid can form in wine glasses, making it appear as if the wine were flowing up the glass. Amazingly this isn't entirely untrue! Wine is composed mostly of water and alcohol. Because alcohol has a lower volatility and is more volatile than water, as wine coats the glass during use, alcohol will evaporate leaving a thin film of water around the glass. This region of higher surface tension pulls on the wine below, which has a lower surface tension due to its higher alcohol concentration. This permits wine to flow up the glass until its own weight exceeds the fore of this phenomenon, eventually allowing it to flow back down creating what looks like “tears of wine” as it flows back down.

This example is actually quite similar to upstream contamination, we see here that mass is being transferred upstream, however wine climbing the walls of a container is not quite the same thing as particles flowing upstream, so how does the Marangoni effect lead to upstream contamination? Remember what we mentioned earlier, the contaminants (chalk and mate) both lowered the surface tension of the water. This creates a surface tension gradient that is capable of exerting a force on the water in the lower container that causes particles to be pulled upward. However, this is not a complete explanation, as mentioned earlier the currents created by the flowing water are thought to play a role in the phenomenon. This might be able to explain why particles are able to overcome the downward force generated by the flowing liquid and flow upstream since the surface tension gradient should not normally generate enough force to pull particles up against the downward stream of water. Since upstream contamination seems to only occur when the height difference between the two containers is low, the force generated by the motion of the pouring water is likely quite small. Unfortunately, understanding how the flow of water contributes to upstream contamination is difficult, after all fluids are notoriously difficult to understand and modelling them often requires a prohibitive amount of computational power.

Ultimately more research needs to be done to fully explain how water can be contaminated by materials that lie downstream. Unfortunately, this phenomenon seems to lack any kind of far-reaching implications for physics, hence there isn't much of a drive to fully understand why it occurs. Fully understanding why upstream contamination occurs might not be as flashy as cutting-edge research into quantum mechanics, but nearly all research is valuable simply by virtue of contributing to our collective body of knowledge. Besides, just because a problem lacks deeper implications does not mean that it wouldn't be interesting to explain!

Professor Spotlight: Dr. Hyunsoo Kim

By Ethan Bradley



Dr. Hyunsoo Kim is a condensed matter experimentalist from Pusan, South Korea. He gained an appreciation for physics in the second year of his high school education, due to a new teacher inspiring him and encouraging him to read books about physics and famous physicists. This sparked an interest in how things worked at the fundamental level that has stayed with Dr. Kim to this day. From there he went on to attend Pusan National University in South Korea where he decided to focus his studies on condensed matter theory because its potential to explain fundamental physics. After obtaining his bachelor's degree, he completed his obligatory military service with the South Korean army and then returned to Pusan National University and completed his masters degree. He initially pursued condensed matter theory, but realized after visiting his friends lab and talking with a professor that experimental work is much more like what he aspired to do when he was younger. Then an opportunity arose for him to study abroad at Iowa State University and to a town with 1/60th the population of Pusan, a change in environment he recalls as a bit of a culture shock. Dr. Kim completed his Ph. D. in 2013 in Experimental Condensed Matter Physics. From there, he worked as a postdoctoral researcher at the University of Maryland before being hired as a staff scientist at the Maryland Quantum Materials center where he took care of low temperature and high field lab facilities. Dr. Kim then received an offer to come to Texas Tech as a research assistant professor in the fall of 2020.

Dr. Kim's current research consists of developing new ultra-precise techniques of measuring self oscillators using inductors and capacitors as probes for various physical values. This allows for studying various materials by studying their changes in oscillations very accurately using simple materials and techniques. He is also exploring the idea of applying this in the investigation of properties of more exotic materials such as topological insulators. Dr. Kim is also very interested in low-temperature experimentation with various techniques. One aspect of physics that particularly intrigues Dr. Kim is being able to understand how the universe around us works by studying just small pieces of it, such as condensed matter or solid state systems. He cites many times where solid state physics were able to predict the existence of particles before they were proven to exist as well as the similarities in the study of binary stars and two body problems in solid state physics. He would advise physics students to put themselves out there more, talk to your professors more and really "sell yourself"!

Since moving to Lubbock Dr. Kim has enjoyed being able to visit nature nearby such as Palo Duro canyon with his family. He also enjoys tinkering with circuitry and coding, as it allows him to create anything he could imagine and is very satisfying to "get it right".

Student Spotlight: Corvus Koithan

By George Collier

What how did you end up at Tech? What led you to decide on physics as your major?

Well, I'm German. I was born in Germany, but my family moved to the US when I was really young. When I was 13, we moved to the Middle East, since my dad's in oil. We ended up moving back to Texas after my sophomore year of high school, so that's why I'm at a Texas university. Then when I visited Tech, I honestly just loved campus in the spring, and I got to meet some physics professors that were super encouraging, which is why I chose to come here. When I was younger, I always wanted to be an engineer like my dad, but as I grew up, 'being an engineer' felt so vague to me, and I started thinking more about what I actually wanted to do. The turning point was when I took my AP Physics 1 class, and I remember talking to my teacher about the AP exam. I was super worried about not doing well, and he just kind of looked at me and went, 'I know you'll do well. It won't be perfect, but I know how much work you've been putting into this. You'll be just fine." It was such a validation to hear from my teacher that my work meant something. My other classes were easy compared to physics, and because I wasn't doing well, I thought I was going to be a failure. But he told me that wasn't true. It was my effort that mattered the most. Honestly, physics was one of the few things I found engaging in school, so that combined with the encouragement of that teacher, I sort of just... landed on physics. It's been my thing for a few years now, and oh man it's hard, but to me that means it's also that much more rewarding when I do well.

Are you currently involved with any research or with the physics department?

I'm not yet involved in research. I definitely want to get involved in some way, so starting to figure that out is one of my plans for this summer. Other than research, I'm in SPS! I'm the Webmaster right now, actually! I've been a member since Fall 2019, so it was cool to become an officer.

How has your experience at Tech been so far? Are there any classes that you have particularly enjoyed?

Honestly, it's sort of complicated, since my first year got cut short due to the Covid-19 pandemic. I'm definitely lucky, though, since I made a ton of friends. I'm in the Honors college, and being in the Honors dorm my first year let me meet so many others students that also emphasized schoolwork. I made friends, somehow fell into loving D&D, and my roommate has been absolutely fantastic! So the good parts of Tech have been really, really good. The not so good parts have sucked, though. I struggle learning online, so once that became a thing, classes became a lot harder. I've done mostly just the basic courses so far but I would say that I enjoyed Math Methods I. Dr. Long is just fantastic, honestly. It's killer hard for me, but she's just so encouraging and helpful that I genuinely enjoy the class. I'm looking forward to Astrophysics II next semester, though!

Do you have any plans for what you will do after you finish your degree?

Uh... that is a... very good question! I'm not sure, honestly. I'm most likely definitely getting a masters, and maybe if I end up loving it all I'll wind up going for a PhD, too. Maybe find a job or something if I can't get into research. It's scary to think about.

Do you have any advice for incoming physics majors?

Oh gosh yes. Firstly- talk to your advisor! Physics is lucky to have Dr. Ungar. She's so amazing and has helped me out with schedules and planning my classes and ensuring I'll have everything I need to graduate. Definitely, absolutely, talk to your advisor. It's all complicated, and long and a little boring and sometimes scary, but they're here to help. And... it'll be okay. It'll turn out fine. You just gotta keep going.

References:

https://en.wikipedia.org/wiki/Upstream_contamination

https://en.wikipedia.org/wiki/Marangoni_effect

https://en.wikipedia.org/wiki/Surface_tension

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