

strong antenna response. With 3D printing, we can imagine fabricating novel borehole antenna shapes sensitive to horizontal polarization.

3.5 Conclusion

Since my last supplemental PEGP in 2019, my students and I have made wonderful progress, and I am proud of them. In particular, I am excited to share my publications. During the attempted merger of ARA and ARIANNA (Sec. 3.3), my field experienced turmoil. The radar research has given me new insight into my field, along with a quality publication read by researchers all over the world. The mathematical physics paper to be published in *Physical Review D* is a great achievement, and my first in that journal. Below are three papers I have published since Fall 2017 as the main author:

1. J.C Hanson *et al.* “Observation of Classically Forbidden Electromagnetic Wave Propagation and Implications for Neutrino Detection.” *Journal of Cosmology and Astroparticle Physics*, n. 7 p. 55 (2018).
doi:10.1088/1475-7516/2018/07/055 and C. Glaser *et al.* “NuRadioMC: simulating the radio emission of neutrinos from interaction to detector.” *The European Physical Journal C*, vol. 80 n. 2 p. 77 (2020).
doi:10.1140/epjc/s10052-020-7612-8
2. J.C. Hanson. “Broadband RF Phased Array Design with MEEP: Comparisons to Array Theory in Two and Three Dimensions.” *Electronics Journal*, vol. 10 n. 4 p. 415 (2021). doi:10.3390/electronics10040415
3. J.C. Hanson and R. Hartig. “Complex Analysis of Askaryan Radiation: A Fully Analytic Model in the Time-Domain.” *Accepted to Physical Review D*. arXiv:2106.00804 (2021).

The papers in item (1) deal with the issue of ray-tracing and radio propagation in ice. I produced a ray-tracing solution that accounted for real ice properties, while arguing that the observation of special cases of horizontal propagation was not explained by ray-tracing. For the second paper in item (1), I was not the corresponding author, but my results were used to create our main simulation package NuRadioMC. I also wrote much of the appendix regarding our ray-tracing calculations. Item (2) is my award-winning phased-array design paper using open-source software. Item (3) is our mathematical physics paper on Askaryan radiation. This list is by no means complete. In my field, collaborations of 10-100 people are common, and every name goes on the author list in alphabetical order regardless of contribution level. Since 2017, I have helped to write many papers for which my work was an integral part, but I am not the “corresponding author.” For a full list of publications, I have provided my CV in the supplemental material.

Thankfully, my field has recovered from the turmoil, and we look forward to many discoveries ahead. I decided to move my remarks about the Whittier Scholars Program to Sec. 5, Advising and Mentoring, because my part of that project was much more about guidance and management than hands-on research work. It falls under the *Boyer* category *scholarship of integration*, and deals with a holistic study of the impact and changing nature of glaciers.