FIVE QUESTIONS WITH DR. DANIEL CHÁVEZ

Magnets: the guides in particle accelerators

In particle accelerators, you need to accelerate and transport a large ensemble of particles, called a bunch. The Radio-Frequency (RF) cavities provide energy and longitudinal focusing to the bunch. In the transverse plane, **magnets** play a fundamental role in the particle's transport and the mitigation of nonlinear effects in the accelerator: quadrupole magnets are in charge of focusing the bunch, dipole magnets bend the beam, sextupole magnets compensate for chromaticity effects, etc. [1].

Could you introduce yourself?

Hi everyone, I am Dr. Daniel Chavez Valenzuela, I was born in Jalpa, Zacatecas, Mexico in 1988.

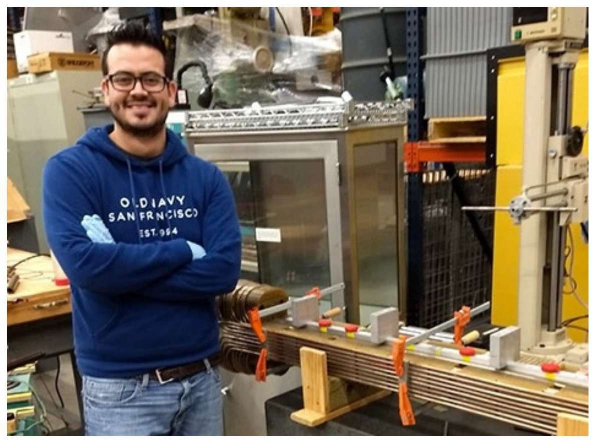

Figure 1. Dr. Chavez in the magnet workshop of Accelerator Research Laboratory at Texas A&M University, College Station, TX, USA.

Could you tell me about your institute and research topic?

Currently, I am working at the *Physics Department of Universidad de Guanajuato* [2], in Leon, Guanajuato Mexico as a full-time professor. Recently, I was awarded level I membership of the National System of Researchers (SNI).

My main goal in this great University is to develop a superconducting laboratory to address Mexican needs and to develop state-of-art technology in-house, something never done before in Mexico. Right now, I focus my time on seven projects to address local needs. In addition, I am collaborating with diverse groups: biomedical engineering, biochemical engineering, and quantum optics. Some of the research topics include:

- Design, modeling, and development of a 7 T (Tesla units $=\frac{Kg}{As^2}$) solenoid for material science applications.
- Design and modeling of a 3T Ion source **magnet** for an electron resonance system for basic research.
- Design and modeling of a normal conducting (20 Celsius) non-uniform magnetic device for excitation of biological material under temperature and atmospheric conditions.

- Design and development of a Cable-in-Conduit (CIC) transversal cable dissector.
- Design and development of a CIC longitudinal cable dissector.
- Design and modeling of a 5 T superconducting dipole using Bi2212 CIC for basic research.
- Design of a Rebco superconducting CIC.

My team is integrated by four Ph.D. students who are working on their dissertations with me, one technician and two engineers.

I am also collaborating as a consultant/staff scientist at *Accelerator Technology Corp.*, a visionary company focused on the development of accelerator technology for medical, agricultural and basic science applications.

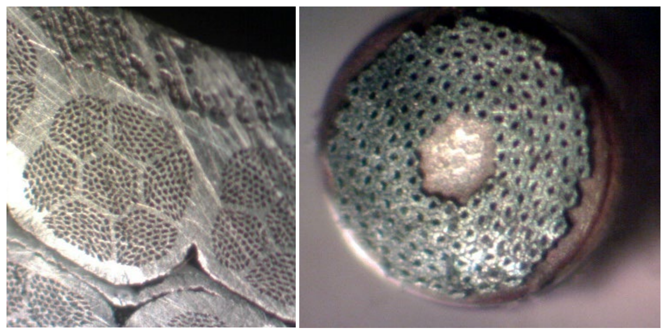

Figure 2. Cable material samples: Bi2122 (left) and NB3SN 8 (right).

My main contribution is the development, design, and modeling of new superconducting technologies for practical applications. We're currently developing a high-current, high-versatility CIC superconductor for its production in long-lengths [3]. This new technology represents a true alternative for the production of superconducting cables with the intrinsic benefit of high thermal stability and higher degrees of freedom, as compared to Rutherford cable, which has a positive impact on the winding and design capabilities of superconducting **magnets**. Another great advantage of this technology is that we can produce it with any of the wind-and-react superconducting wires presently available (Nb_3Sn, MgB_2, Bi_{2212}, Bi_{2213}) without current degradation due to its manufacturing process.

I am also involved in the design and modeling of CIC related technology: including detachable splice-joints, methods for developing cabling machines, robotic windings, systems for the monitoring of the integrity of CIC in the production line, and magnetic modeling in general.

How or why did you choose that topic?

I chose **magnet** design and applied superconductivity thanks to the suggestion of a friend of mine, *Luis Medina*, who told me (back in 2013) that his Ph.D. advisor was looking for someone to send to Texas A&M University to train him on superconducting **magnets**. I knew nothing about superconductivity, and I was planning to study gamma-ray spectrometry for my master's degree; however, the superconductivity called my attention. The intrigue that surrounds the superconductivity theory captivated me. On one hand, you can model and create such interesting magnetic fields. On the other hand, your models can provide solutions to practical problems in various areas, including medical Physics, Engineering, and Basic Science. I am very thankful to both, *Dr. Luis Medina* for suggested me the field that became my way of living, and with my supervisor and friend *Dr. Mauro Napsuciale,* who trusted and supported me during both the masters and the Ph.D. programs.

Right now, what is the biggest challenge of your work?

Nowadays, the development and application of high-temperature superconductors is a hot-topic, many challenges surround this topic: “How to produce **magnets** reliably using tapes, with minimum current degradation? and How to redistribute the stress due to Lorentz forces, thermal compaction ratios, etc.?”. However, the use of wind-and-react superconductors imply the use of controlled atmosphere and high-temperature heat treatments to form the superconductor, while the cable is placed in the magnet. Here, material science plays a very important role. Thus, many effects take place at the same time, and in some cases, the technology to produce longer magnets (such as the ones required at large accelerators, like the Large Hadron Collider) with these new materials, has not yet been developed.

What do you think that will be the future of your research area?

I am very confident that within the next decade or two, the present efforts in the development of new high-temperature superconductors (in diverse topologies) will allow us to produce them in long-lengths, and with much fewer requirements in the reaction process. This will have a profound impact on the design capabilities that will allow us to achieve much higher magnetic field, in the 20-30 T range.

References

[1] D.A. Edwards and M.J. Syphers, *An Introduction to the Physics of High Energy Accelerators*, WILEY-VCH Verlag GmBH & Co. KGaA, Weinheim, 2004.

[2] Division de Ciencias e Ingenierias main page, http://www.dci.ugto.mx/

[3] D. Chavez, J. Brietshopf, T. Elliot, T. Kellams, P., McIntyre, A. I. Sattarov, *CIC Cable technologies for high-current windings*, IOP Conf. Ser.: Mater. Sci. Eng. **502** 012177. 2019.