Abstract: Radiation therapy has long been one of oncologists' most effective weapons against cancer, and today's state-of-the-art technology allows medical physicists to tailor advanced patient-specific treatments. However, new radiation therapy methods which can increase the local effectiveness of tumor cell killing while sparing healthy tissues are still needed. Due to gold's high atomic number, gold nanoparticles exhibit strong interactions with the X-ray photons used in radiation therapy, leading to localized radiation dose enhancement. This dose enhancement is being systematically investigated in a collaborative project between physicists at the University of Texas at San Antonio and medical physicists at University of Texas Health San Antonio's Mays MD Anderson Cancer Center. Macroscopic physical dose enhancement has been systematically determined using a novel measurement technique on a clinical brachytherapy setup. Experimentally determined dose enhancements of up to ~5% have been measured; these observed enhancements agree well with Monte Carlo simulations. Intriguingly, a macroscopic physical dose enhancement of 5% is a volume average—the dose enhancement in the microscopic vicinity of a nanoparticle is much higher. This microscopic enhancement may be determined via the radiobiological effects on cells. Recently we have investigated the radiobiological effects of irradiation in a brachytherapy setup for C33a cervical cancer cells treated with PEGylated gold nanoparticles. We have carried out imaging flow cytometry to quantify the effects of the treatment on cell viability and apoptosis, using Zombie Aqua and Annexin V staining, respectively. Cell survival curves were fit with the linear quadratic model. We then determined the radiation dose required to achieve the same cancer cell killing effect with vs. without the presence of gold nanoparticles. These data indicate a 12% radiosensitization enhancement at nanoparticle concentrations that were 20 times lower than those in the macroscopic experiments described above. The expected macroscopic dose enhancement is 0.25% at this nanoparticle concentration, whereas the measured radiosensitization is almost 50 times larger. These data represent a starting point from which we can achieve even higher radiosensitization enhancement via improving our understanding of nanoparticle cellular uptake and antibody targeting.

Bio: Kathryn (Katie) Mayer is an Associate Professor in the Department of Physics and Astronomy at the University of Texas at San Antonio, where she has been a faculty member since 2014. Her group studies metallic nanoparticles and their biomedical applications. Katie is originally from Cleveland, Ohio and earned her bachelor's and Ph.D. in Physics at Rice University, where she was a member of the Hafner Lab. After that she did postdoctoral research in Chemistry at UT Austin and at Tufts University before joining UTSA's faculty as a member of the Biophysics group.