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Astronomers reach for the stars for new cancer therapy

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By Pam Frost Gorder, Research Communications

Astronomers' research on celestial bodies may have an impact on the human body.

Ohio State astronomers are working with medical physicists and radiation oncologists to develop a potential new radiation treatment — one that is intended to be tougher on tumors but gentler on healthy tissue.

In studying how chemical elements emit and absorb radiation inside stars and around black holes, the astronomers discovered that heavy metals such as iron emit low-energy electrons when exposed to X-rays at specific energies.

Their discovery raises the possibility that implants made from certain heavy elements could enable doctors to obliterate tumors with low-energy electrons, while exposing healthy tissue to much less radiation than is possible today. Similar implants could enhance medical diagnostic imaging.

Sultana Nahar, senior research scientist, and Anil Pradhan, OSU professor of astronomy, have used discoveries made while examining black holes and quasars to find better ways to battle cancer cells.

Ohio State senior research scientist Sultana Nahar announced the team's computer simulations of the elements gold and platinum, and the design of a prototype device that generates X-rays at key frequencies, at the International Symposium on Molecular Spectroscopy in June.

Their simulations suggest that hitting a single gold or platinum atom with a small dose of X-rays at a narrow range of frequencies — equal to roughly one tenth of the broad spectrum of X-ray radiation frequencies — produces a flood of more than 20 low-energy electrons.

"As astronomers, we apply basic physics and chemistry to understand what's happening in stars. We're very excited to apply the same knowledge to potentially treat cancer," Nahar said.

"We believe that nanoparticles embedded in tumors can absorb X-rays efficiently at particular frequencies, resulting in electron ejections that can kill malignant cells," she continued. "From X-ray spectroscopy, we can predict those energies and which atoms or molecules are likely to be most effective."

Nahar and Anil Pradhan, professor of astronomy at Ohio State, discovered that particular frequencies of X-rays cause the electrons in heavy metal atoms to vibrate and break free from their orbits around the nucleus, creating what amounts to an electrically charged gas, or plasma, around the atoms at the nanometer scale.

They have thus dubbed their medical concept Resonant Nano-Plasma Theranostics (RNPT) — the latter word a merger of "therapy" and "diagnostics."

"From a basic physics point of view, the use of radiation in medicine is highly indiscriminate," Pradhan added. "Really, there has been no fundamental advance in X-ray production since the 1890s, when Wilhelm Roentgen invented the X-ray tube, which produces X-rays over a very wide range."

No advance, that is, until now.

"Together with long-time collaborator and medical physicist Yan Yu from Thomas Jefferson University Medical College, we've developed the RNPT methodology, which we hope will have far-reaching consequences for X-ray imaging and radiation therapy," Pradhan said.

Physicists have long known that electrons orbit the nuclei of atoms at different distances, some close to the nucleus and some farther away. When one of the close-in electrons is lost, a far-out electron may drop in to take its place, which releases energy. This is called the Auger effect, which was discovered in 1922.

Often the energy is strong enough to kick out a second electron, called an Auger electron. The same process could also result in the emission of light particles, or photons, at specific energies or frequencies, the most prominent of which are called K-alpha X-rays.

The astronomers believe that K-alpha X-ray frequencies kick the close-in electrons out of heavy metal atoms such as platinum, causing many far-out electrons to fall in, and many more electrons to be kicked out. These free Auger electrons are low in energy but great in number, and could feasibly bombard nearby malignant cells and shatter their DNA.

While typical therapeutic X-ray machines such as CT scanners generate full-spectrum X-rays, hospitals could employ RNPT using only K-alpha X-rays, which would greatly reduce a patient's radiation exposure. That's the function of the proof-of-principle device that the team has constructed.

Platinum already is used in the chemotherapy drug cisplatin, where it delivers the drug by binding to malignant DNA.

"This work could eventually lead to a combination of radiation therapy with chemotherapy using platinum as the active agent," Pradhan said.

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