

The Search for Dark Matter

Physicists are moving in droves to this field, as the subject has become the big physics problem after the discovery of the Higgs boson, ET's Hari Pulakkat writes

For over 20 years, Pijushpani Bhattacharjee made a living by worrying about exotic stuff far away in the universe. Specifically, he has worked on the origin of the mysterious high energy cosmic rays and the even more mysterious dark matter, postulated by physicists like him to exist. No one can see this dark matter but everyone can sense it in the swirl of galaxies. After staring at equations for two decades, this physicist at the Saha Institute of Nuclear Physics in Kolkata decided to get his hands dirty: he would participate in a big experiment to detect dark matter.

Dark matter experiments have increased in frequency around the world, as scientists have become more and more desperate to pin down this elusive substance. It was not that dark matter was rare or that we learned about it recently. About 80% of the matter in the universe consists of this strange stuff. Physicists have known about its existence for five decades, as they have realized that galaxies do not have enough visible matter to hold them together.

Scientists don't know what it is or how it interacts with normal matter. Light does not shine off it, and so it came to be called dark matter.

Around 2008, Bhattacharjee decided to take part in an experiment in Canada. Called Picasso, it consisted of immersing superheated liquid deep underground and creating a tiny droplet of a special liquid in it. When a dark matter particle hits it, this droplet would vaporise and become a bubble, creating sound waves in the process. Bhattacharjee's team made the simulations that would help in

the detection of the sound waves when they come. "The challenge is to identify all the background noise and eliminate everything other than the dark matter signal," says Bhattacharjee. Physicists expect a few hits to the droplet in a year.

THERE HAS BEEN NONE IN FIVE YEARS.

The other major dark matter experiment in the US, called Lux, has also not found any particle yet. Bhattacharjee has now got involved with an Indian experiment to detect dark matter, deep in the mountains near Ooty and to be ready within five years. For dress rehearsal, Indians are trying to build a prototype detector in the Jaduguda uranium mine in Jharkand, or find some other place if the Atomic Energy Commission does not clear the venue. "There is no guarantee that current experiments will find dark matter," says Rupak Mahapatra, associate professor at the Texas A&M University. "So in five years, the Indian experiment will become attractive."

Mahapatra, an IIT Kharagpur alumni, is one of the key motivators for this project and intends to bring the best available technology to Ooty. Last week, he was the recipient of a big but unspecified amount of funding from the US Department of Energy and the National Science Foundation to build the next generation of dark matter experiments, using exquisitely tailored detectors ten times more sensitive than the incumbents. Physicists are now moving in droves to this field, as dark matter has become the big physics problem after the

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Illustrations: ANIRBAN BOHA

discovery of the Higgs boson. "We are closer than ever to detecting dark matter," says Sudhir Vempati, associate professor at the Indian Institute of Science (IISc) in Bangalore.

Vempati, a theorist, works on the so-called physics beyond the Standard Model. Our visible universe consists of particles and forces, and the Standard Model of particle physics provides a beautiful framework to describe them in one overarching theory. But it has missing pieces. The Standard Model does not incorporate gravity. It does not explain dark matter either. So physicists are looking for extensions of the model, and theorists like Vempati have begun to look more closely at dark matter. "It will be a tremendous input to our understanding and theory of elementary particles," says Stefano Profumo, associate professor of physics at the University of California in Santa Cruz.

Profumo's work consists of looking for signals that may be connected with dark matter. Give him a signal, a weird phenomenon that you do not understand, and he will tell you whether dark matter has anything to do with it. Profumo likens the current intimations of dark matter with the discovery of radioactivity.

At the end of the 19th Century, the phenomenon of radioactivity gave the first hint to physicists that there was something out there in the sub-atomic realm, something unusual and rich that could one day be exciting and useful.

Investigations of radioactivity led to the discovery of the atom and a world of immense possibilities. Where will dark matter lead us?

There is a tremendous amount of matter in the universe. Our own galaxy contains half a trillion stars, and there are 100 billion such galaxies in the universe, and more dust and gas than the stars. All of this together forms just 4% of the universe. Dark matter constitutes 23%, and the rest is

another mysterious entity called dark energy. When you consider matter alone, the visible stuff forms only 20%, but it is enough to make such a rich and sophisticated world that includes us. Is there a similarly exciting world happening around dark matter?

Current theories say that there won't be too many particles of dark matter.

But do they interact with normal matter? Are some of the mysterious phenomena that we do not understand due to dark matter? Do living beings interact with dark matter? There are many such questions that remain unanswered till we find out what constitutes dark matter. It is actually a bigger and more significant problem than Higgs boson. "We knew where to look for the Higgs boson," says Mani Tripathi, professor of physics at University of California in Davis and a long-time dark matter hunter. "Dark matter can be anywhere."

The search for dark matter can yield some immediate practical benefits. The detectors are so sophisticated and sensitive that they can be used to detect minute sources of radiation. Applications abound in security and healthcare. These applications may pale into insignificance when we discover the substance, and if it turns out to interact with visible matter. We would then enter a new world of science and technology, rich enough to occupy the best minds for a long time.