HINODE: Inside Solar Storms

Solar flares are among the most titanic explosion in the solar system. A typical flare can supply a human civilization with enough energy for 10,000 years. Astronomers have studied solar flares for the last century but only in the last 50 years have their impacts to radiation and communications technologies become more than just a nuance to just be endured. Billions of dollars in technology and even human lives now hang in the balance. Back in the 1800's physics Joseph Von Fraunhoffer invented the spectroscope which would turn out to be one of the most important tools of astronomy in the centuries to come. By passing sunlight through the instrument, rainbow of light was created cross by hundreds of black lines. It was soon discovered that these lines were the fingerprints of individual elements in the sun heated to high temperature. Each element produces light at only specific wavelengths. No two elements have exactly the same patterns of lines which look something like the product barcodes that you see in a supermarket. Thanks to the spectroscope, the astronomers could now determine the elementary composition of stars; planetary atmospheres, inevitably, without actually having to go there and take direct samples. During the first half of the 20th century, the precise relationship between these atomic lines and other physical properties of the gas were finally worked out. Astronomers could now use the spectroscope to determine the exact temperature of a gas, its density, its motion; how much turbulence was present, whether the gas was in rotation and whether a magnetic field was present. By combining photography with spectroscopy, a new technique emerged that revealed the sun's character far beyond what photography alone could record. In 1890 George Ellery Hale build an instrument called a spectroheliograph at the Massachusetts Institute of Technology. He first broke sunlight into spectrum then isolated one of the atomic lines that corresponded to hydrogen heated to 10,000 degrees. By using this instrument as a very precise optical filter, he could see the sun through hydrogen light only. What was more important was that Hale could now isolate and study one facet of the sun. Its hydrogen gas heated to 10,000 degrees. The photographs revealed for the firs time, a complex solar surface laced with ribbons and bands of mechanic energy confining supper heated hydrogen atoms. On many occasions, his studies of sun spots even captured sudden eruptions or hydrogen alpha flares that were completely invisible in normal optical photographs. At the heart of every theory of why solar flares occur is a specification of the temperature, density, energy, and magnetic field inside the flare and how these change in time and space. Just as viewing the landscape without a focus glasses only gives a rough idea of what is around you. Astronomers are also hampered by resolution when they try to specify the physical parameters of a flare. Sometimes the most interesting phenomenon occurs in parts of the magnetic spectrum that cannot be studied from the ground. For example, the X-rays from the heart of a solar flare are completely blocked by earth's atmosphere so only satellites can clearly see these details. One of the most sophisticated solar satellites launched today is HINODE. It is a complex observatory with a far more sophisticated array of instrument designed to probe the detailed physics of magnetic fields; coronal heating and the origins of solar flares. I recently talked with Dr. George Doshek; the solar physicists; he's the solar flare expert who uses HINODE to investigate solar flares. He is the head of the Solar Terrestrial Relationships Branch in the Space Science Division as the Naval Research Lab in Washington D.C. George can you tell us a little bit about the physicists HINODE satellite and its instruments?

George:

Yes the HINODE satellite is a Japanese satellite launched at the end of September and around 2006. It's designed to study the atmosphere of the sun in space. You may be surprised to know that the sun has an atmosphere. People often; people are surprised at this but the sun's atmosphere extends from the surface to the earth. We don't know what causes the atmosphere but because the atmosphere exists, the sun has a profound affect on the earth in what we call space weather. Now the sun's atmosphere emit white light, it emit X-rays, it emit ultraviolet light. The X-rays in ultraviolet light can't penetrate our own atmosphere so we have to study these emissions in space. So HINODE has three instruments on it. One is a white light telescope designed specifically to look at the sun in white light so we can see the surface of the sun but it can also see a little bit up into the atmosphere. That instrument was provided by the Japanese with contribution from Lockheed and NASA from the United States. It's also an X-ray telescope on the satellite and the X-ray telescope looks at the higher temperature part of the sun's atmosphere. The sun surface is relatively cold and only 5500 degrees Kelvin. You think that's hot but it really isn't compared to the upper part of the atmosphere which goes ups to one to three million degrees. The X-ray telescope sees this part of the atmosphere and it makes movies of features that we see in the atmosphere; explosions and how these explosions propagate outwards towards the air sometimes. Finally there's another instrument called an extreme ultraviolet spectrometer. Now a spectrometer is an instrument that takes whatever light it's looking; in this case ultraviolet; and it breaks it up in kind of rainbow and in the rainbow we can see fingerprints of all sorts of things going on the gas that's submitting the light. We can tell what element the gas is made of; we can tell what the temperature of the gas is; we can tell what the density is of the gas and we can tell its motions and its flows. Now this instrument was provided by the United Kingdom in a consortium with NASA as well in the Naval Research Lab of which I'm a part of; and I should also mention that the X-ray telescope was provided the Center of Astrophysics in the United States which made contributions also from the Japanese. The Norwegians have also contributed to the mission; they supplied the ground support equipment for our instrument; the extreme ultraviolet spectrometer and they also provide tracking station. So basically HINODE of all the Japanese satellite that launched in Japan is really an international mission to study the sun by scientists all over the world.

So what's the big question that you think that HINODE will be able to answer about solar activity?

George:

The big question is what causes it? What heats the atmosphere and how is the energy stored, how is it released and how does it propagate to the earth? Would like the trace the origins of the atmosphere down to the surface of the sun; I believe I said this on the surface was relatively cold at 5500 degrees. There most of the emission occurs in what we call white light or invisible light. Now to go a little higher, we have to go to shorter wavelengths but not as short as we have to go to see the hottest part of the sun's atmosphere. Now also in the atmosphere of the sun, there's an explosion called solar flares and kernel mass ejections. When flare occur, the temperature of the atmosphere can go up to 20 million degrees so here the X-rays are really important; even in the extreme ultraviolet we can still see this radiation because of the nature of the atomic emissions from atoms. So, by looking at the atmospheric structures that we see and the X-ray and the extreme ultraviolet and the visible, we hope to put everything together and come up with a physical picture of what actually causes the eruption. We know that it somehow has something to do with the magnetic field of the sun; the mechanical motions and the surface are stressed to magnetic field and then the magnetic field releases these stresses and heats gas even further but we don't know the details of this and HINODE, we hope, will make really strong and great contributions towards solving this problem.

And how do you think this knowledge about solar activity is going to have practical applications here on earth?

George:

Well the suns' atmosphere produces these mass ejections and flares very closely to its surface but he affects of these; radiation and particles that are accelerated, especially in the ejections of mass, reach the earth and they can do a lot of damage near the earth. For example, they can cause satellites to fail, they can disrupt communications on the earth, they can cause power outages, they can heat the atmosphere and cause the drag coefficients; the satellites to change that are harder to track. They are hazardous to astronauts; if we wish to go to Mars or one of the other planets; we have to take the sun into account. So to be able to predict when these disturbances are going to occur helps us to do things to mitigate the damage; to avoid it entirely.

Over the years astronomers have created many different kinds of technology to let them study the solar surface in great detail. At first, astronomers simply sketched or photographed what they saw. With the new advent of new photographic techniques and satellite observations, even clear views of the sun are now common place but astronomers need far more than just pictures to truly understand the sun.

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