Haimin Wang is a leading expert in observational solar flare research with a focus on the areas of evolution of magnetic fields associated with flares. He joined NJIT in 1995 and was promoted to distinguished professor of physics in 2004. Along with leading NJIT’s new multidisciplinary Institute for Space Weather Sciences, he serves as the chief scientist of the university’s Big Bear Solar Observatory in California.

One of the nation’s leading public technological universities, New Jersey Institute of Technology (NJIT) is a top-tier research university that prepares students to become leaders in the technology-dependent economy of the 21st century. NJIT’s multidisciplinary curriculum and computing-intensive approach to education provide technological proficiency, business acumen and leadership skills. With an enrollment of 11,560 graduate and undergraduate students, NJIT offers small-campus intimacy with the resources of a major public research university. NJIT is a global leader in such fields as solar research, nanotechnology, resilient design, tissue engineering and cybersecurity, in addition to others.

Q&A

Haimin Wang

Director of NJIT’s Institute for Space Weather Sciences and Chief Scientist at the University’s Big Bear Solar Observatory in California

What is space weather and how does it affect us?

When active regions on the surface of the Sun explode, they release powerful bursts of electromagnetic radiation, known as solar flares, and charged particles, known as coronal mass ejections. Collectively, these phenomena cause the bulk of what we call space weather. As the complexity of engineered systems on Earth increases, as new technologies are invented and deployed, and as humans venture ever further beyond Earth’s surface, both human-built systems and humans themselves become more susceptible to the effects of the planet’s space environment. On Earth, these storms can disrupt power grids and cause radio blackouts, among other consequences.

What is the Institute for Space Weather Sciences?

With these growing vulnerabilities in mind — and in response to urgent calls from government agencies, insurers, electrical grid operators and others for more sophisticated research, forecasting and mitigation strategies — NJIT formed the multidisciplinary Institute to advance both theoretical and applied research on our civilization’s interface with these space weather events. This new entity combines the strengths of the physicists and engineers at our Center for Solar-Terrestrial Research (CSTR) with powerful computing and mathematical capabilities at the Center for Computational Heliophysics, which partners with NASA’s Advanced Supercomputing division at the NASA Ames Research Center, and the Center for Big Data.

How do these centers collaborate?

The Center for Solar-Terrestrial Research is events-driven. With powerful imaging instruments, such as our 1.6-meter Goode Solar Telescope at the Big Bear Solar Observatory and radio telescopes at Owens Valley Solar Array, we are able to study the physical mechanisms of flares and coronal mass ejections as they occur. What we need to enhance our capabilities is data analytics. With ever-evolving data processing and image analytics, the algorithms and techniques that computer scientists employ can extract even more information from our images.

Modelers and data experts will also help us detect patterns that can be missed by conventional analyses. For example, CSTR has a huge amount of hydrogen-alpha emission data from solar flares dating back to the 1950s. We aim to better understand the patterns of solar activity over various solar cycles, which should lead to better space weather forecasts.

How will this knowledge help us prepare?

With real-time information on all of the relevant conditions, meteorologists are able to track a hurricane and determine where it will make landing. In a similar manner, high-resolution observations and cutting-edge data analytics should allow us to track the propagation of solar eruptions and the solar wind.

So if we spotted a region on the Sun with potential activity and could predict the potential for its eruption, we should be able to also estimate its path. This would assist in determining whether a spacecraft should go into “safe mode” by powering down vulnerable instruments and turning its solar panels away from the Sun. As another example, forecasts of radio wave bursts from the Sun, which can also knock out GPS tracking, would be vital to GPS-guided technologies such as missile launches or self-driving cars. Furthermore, forecasts of coronal mass ejections are important if aircraft are flying over the North Pole, and as such, might lose HF radio contact and need to be rerouted. You can imagine that the government and commercial sector are keenly interested in this capability!

What new solar research is on the horizon?

Using our solar and radio telescopes, we can now trace the eruption of solar active regions from the Sun’s surface and into the solar corona, giving us ever-greater insights into triggering mechanisms. By combining our observations of the magnetic fields with sophisticated models, we’re now creating 3D models of the Sun’s magnetic field lines, and even 4D if you add in the dimension of time.

With partners in other research centers, such as Jason Wang, a computer scientist who develops deep learning technologies, we are beginning to be able to predict solar flares. In research recently published in the Astrophysical Journal, we demonstrated how we trained a machine-learning algorithm, called random forest, to predict the occurrence of a certain class of flares in a given active region within the next 24 to 48 hours.

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