

News release -- for immediate release  
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## Mixing an icy cocktail to safely cool a hot plasma

**SAVANNAH, GA (Nov. 16)** -- A shot of icy chemical cocktail – that’s the promising solution to controlling hot plasmas in fusion devices, researchers say.

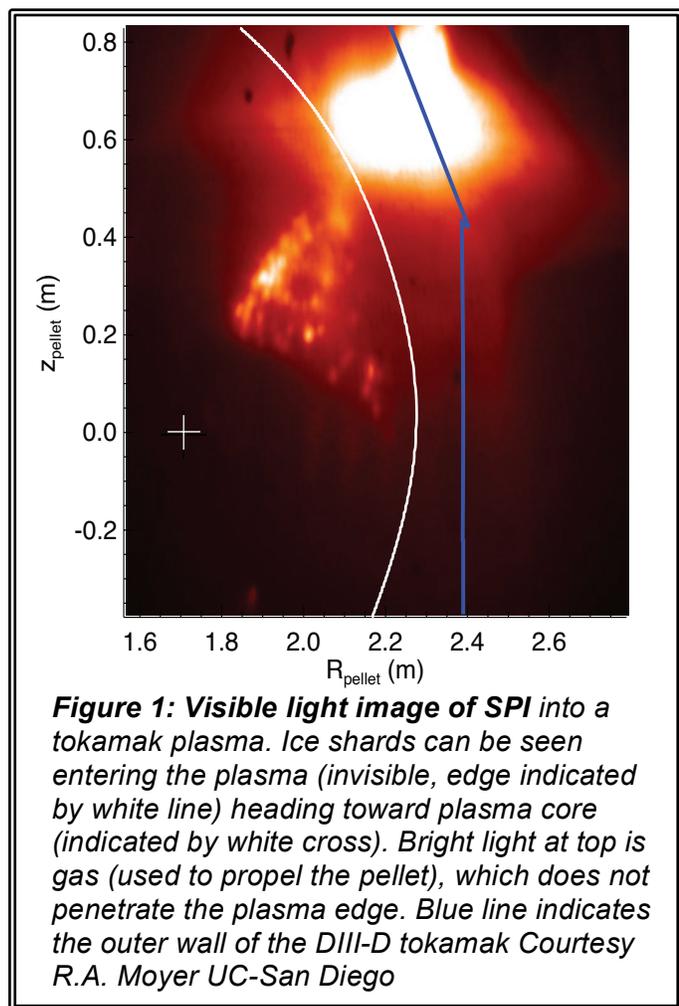
Recent experiments conducted at the DIII-D National Fusion Facility at General Atomics (GA) show promise in an innovative approach to controlling unwanted hot spots inside the devices, called tokamaks, that contain energy-producing fusion plasma at temperatures hotter than the Sun’s core.

Sometimes researchers need to cool the hot plasma very rapidly, explains GA physicist Nicholas W. Eidietis of recent experiments with ice pellet injection, “But cooling the plasma too much or too little will both cause problems. These experiments show we have control over the plasma shutdown.”

Dr. Eidietis along with a team led by Dr. Daisuke Shiraki of Oak Ridge National Laboratory have “chilled out” unwanted hot spots inside the fusion vessel by injecting pellets of frozen neon and deuterium straight into the hot plasma.

While he calls the tokamak a promising fusion reactor design for developing fusion energy, a significant challenge are unwanted events called “disruptions.” Disruptions occur when thermal and magnetic energy in the plasma is rapidly lost -- in a few thousandths of a second. Disruptions result in very large heat loads and mechanical forces on the walls surrounding the plasma, which could damage the reactor.

One promising approach for mitigating damaging effects of disruptions is the rapid injection (100’s meters per second) of a large ice pellet into the hot plasma (see Figure 1). The pellet shatters before entering the tokamak, avoiding the possibility of an icy “bullet” damaging the



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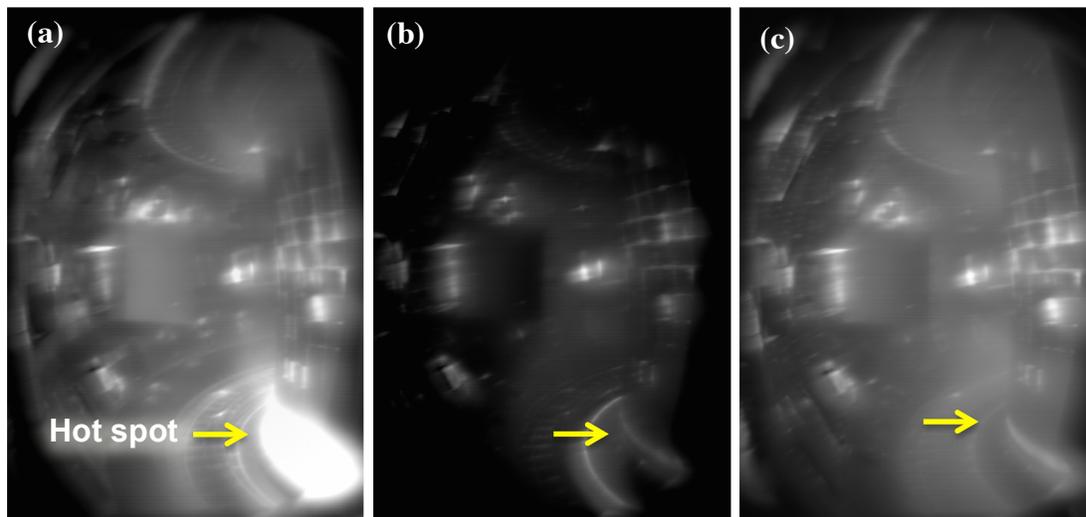
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...vessel wall, a process that gives the technique its name, Shattered Pellet Injection (SPI).

The pellet fragments cause the plasma to radiate away its energy uniformly as light, reducing localized heating of the tokamak wall and the mechanical forces exerted on the machine. This technique, developed by Oak Ridge researchers, has been demonstrated at DIII-D by a team of scientists from GA, Oak Ridge, University of California-San Diego and Lawrence Livermore National Laboratory.

Recent progress in SPI, presented at the 57<sup>th</sup> Annual Meeting of the American Physical Society Division of Plasma Physics, in Savannah, GA., uses frozen pellets composed of neon and deuterium (an isotope of hydrogen). This allows researchers to control various aspects of the disruption by varying the pellet “icy cocktail” mixture. This will be important in future large tokamaks such as ITER, now under construction in France by an unprecedented scientific partnership involving 35 nations.



**Figure 2 -- Icy chemical cocktail at work:** Infrared images of disruption heat loads on the first wall of DIII-D tokamak, when mitigated by pellets composed of (a) pure deuterium (b) mixture of deuterium and neon and (c) pure neon. Bright spots indicate high wall temperature. Primary heat loads occur where magnetic field lines intersect the wall, near bottom right of each image (hot spot indicated by arrow). Images courtesy of C.J. Lasnier, LLNL

In ITER, design constraints require tuning of certain disruption parameters to be within allowable ranges. For example, a very fast decay of the plasma current (due to over-cooling of the plasma) can induce large electrical currents and forces in the tokamak structure that can damage parts of that structure, while a very slow decay (due to too warm of a plasma) causes current from the outer “halo” region around the plasma to flow through the vessel wall, also resulting in large forces on the device. Successful mitigation of the disruption requires the current decay rate stay in the “Goldilocks Zone” away from both of these limits.

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...The lessons of the fairy tale applies to plasma physics as well as Goldilocks, Eideitis explains: Researchers don't want plasma to be too hot, to travel too fast or too slowly. Plasmas in a tokamak, especially the size of ITER, which will be four times the size of DIII-D, need to be just right.

The techniques demonstrated in this work provide a simple means of controlling disruption characteristics by adjusting the mixture of gases cooled to form the ice pellet. An example of this is shown in Figure 2, where the amount of neon in the pellet mixture is varied between three different disruptions, resulting in significant differences in the concentrated heat loads transmitted to the machine wall. Other properties of the disruption, such as the plasma current decay and the flow of halo currents, are also found to vary significantly based on the choice of pellet mixture.

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Abstract:

TI2.00006 : Optimization of Massive Impurity Injection Techniques for Thermal Quench Mitigation and Current Quench Control on DIII-D

[Session TI2: Low Temperature Plasmas, Stellarator, and Disruptions](#)

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