Fast liquid Lithium "shower" injector

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Purpose: to mitigate disruptions

How can ~100 grams of material be injected quickly into a tokamak to both prevent runaway electron formation & radiate away the thermal quench energy?

- Has to be fast… < 5 milliseconds from trigger to delivery across the central axis
- Has to be reusable, and easy to reload
- Has to be armed and ready to fire any time
- Should minimize side effects….such as holes in armor on opposite wall, or unwanted propellant gas load, or residual contamination

Issues

- Gas guns are borderline too slow, especially for high Z delivery. Conductance limitations are problematic if valves are far away.
- A 100-gram bullet is out of the question (at 1 km/sec, it carries 50 kJ of energy).
- An equivalent of a shotgun blast (thousands of small pieces) might do the trick.
- But gas loads, and acceleration times have to be minimized, as well as any sabot debris.

Consider an electromagnetic "flyer plate" launcher

- A sufficiently strong, rapidly pulsed magnetic field under a conducting plate, will cause it to fly away.
- Speeds of 1 km/sec are readily achievable.
- Consider a dish with a thin layer of molten lithium (0.5 g/cc, implies ~10-15 cm diameter)
- A liquid conductor pancake will break-up in flight, into many small droplets.
- The tray can be reloaded from below with a fill tube, with more liquid, for the next shot.
- The injector should be located somewhere in the bottom of the vessel armor or divertor, to have gravity help keep the liquid in the tray, while it waits for a launch command.

A launcher prototype system needs some design work.

- How fast do the fields have to rise? How much current is needed in the coil launcher? Launcher needs to be at ~ 200 degrees Centigrade, for liquid lithium. Would solid lithium break up as well?
- How efficient is the injector? 50 kJ in the overall payload may mean a large amount of stored energy in the launcher.
- Lithium obviously has conditioning effects. What about hydrogen pumping while you wait? What about hydrogen (tritium) trapping later? What about lithium buildup? What about lithium dust?
- How do the injected droplets interact with the main or post-disruption plasma?
- How fast does the toroidal current decay as a result of this injection? Too fast is also not good, as resulting electromagnetic disruption forces may be too large for ITER to handle.
- Can we design and build a prototype system on NSTX, given that NSTX already uses lithium, and it may have secondary uses as a lithiumization tool?