INSTITUTE FOR ENERGY AND ENVIRONMENTAL RESEARCH

6935 Laurel Avenue, Suite 201
Takoma Park, MD 20912

Phone: (301) 270-5500
FAX: (301) 270-3029
e-mail: ieer@ieer.org
http://www.ieer.org

Statement of Hisham Zerriffi

IEER Press Conference
July 15, 1998, National Press Club

Good morning. My name is Hisham Zerriffi, and I am a Project Scientist at the Institute for Energy and Environmental Research. I would like to cover two topics this morning. The first is an overview of the types of fusion research which could lead to pure fusion weapons. The second is how our technical interpretation of the Comprehensive Test Ban Treaty led us to conclude that some of the major projects of the nuclear weapons states would be illegal under the CTBT.

In current thermonuclear weapons, the part popularly called the "hydrogen bomb" is triggered by a fission explosive. This is necessary to create the high temperatures -- greater than those in the interior of the sun -- and the high pressures needed for a large number of nuclear fusion reactions to occur in a very short time. No fusion explosion that has yielded an amount of energy larger than the energy input has ever been artificially created without a fission trigger. This is because the electrically charged gas (called a plasma) tends to fly apart before the explosion unless there is sufficiently powerful and highly symmetric compression of the material in a short enough time. This requires rapid, compact "drivers" of high energy to replace the fission explosive.

Major advances in substituting the fission trigger by non-nuclear components need to be made before the scientific feasibility of pure fusion weapons can be established. Until now, the hurdles have been too huge to overcome. But experiments are now being conducted and devices are now under construction that may achieve explosive thermonuclear ignition without fissile materials.

There are three broad classes of explosive fusion research:

Inertial Confinement Drivers: These drivers use laser or particle beams to compress a fuel pellet and create the necessary conditions for a fusion explosion to occur. The high speed at which the nuclei of deuterium and tritium are imploded provides the particles with an inertia that keeps them moving towards each other even as the thermonuclear reaction causes the mass to explode -- hence the term "inertial confinement fusion" to describe the process.

Z-Pinch Drivers: These devices use electrical currents to evaporate a bundle of wires. The bundle is pinched by magnetic fields, causing the atoms to stop suddenly. This abrupt stop converts the kinetic energy of the particles into x-rays. The process is somewhat analogous to the conversion of the kinetic energy of a car into heat during sudden braking. Since x-rays can be used to compress a fusion fuel pellet, the high level of x-ray energy achieved by the wire-array z-pinch makes it very interesting to fusion researchers. The largest wire-array z-pinch is at Sandia National Laboratory in new Mexico.

Magnetized Target Fusion Drivers: In magnetized target fusion an initial plasma is created by electromagnetic means. Conventional high explosives then compress the plasma and the conditions for fusion ignition are created. The densities and compression times for MTF are lower than for ICF because the plasma is already slightly compressed and heated before the implosion. The combination of high explosives and electromagnetic energy sources, both of which might be able to become miniaturized, make this a particularly dangerous facility.

It is necessary to note that these devices are complementary. Lasers cannot be miniaturized into deliverable weapons. But NIF could be more easily used to design the thermonuclear fuel targets than the other two devices. The Magnetized Target Fusion experiments at Los Alamos could be used to perfect the use of chemical explosives in fusion weapons, while the wire-array z-pinch can generate intense x-rays, similar to those that are produced by the fission portion of present-day thermonuclear warheads.

This provides a general picture of the state for explosive fusion research at the moment. While no current device can achieve ignition, there are at least three devices which could achieve ignition early in the next century: the National Ignition Facility, the Laser Mégajoule, and X-1 (the planned next generation of z-pinch devices). However, all three of these machines would be illegal under Article I of the Comprehensive Test Ban Treaty.

Article I of the Comprehensive Test Ban Treaty prohibits all nuclear explosions by all signatories, regardless of nuclear weapons status. This is significantly different than the Non-Proliferation Treaty which had different prohibitions for nuclear and non-nuclear weapons states. Any interpretation of Article I must begin with an understanding and definition of nuclear explosions. It is unfortunately not simple to define a fusion nuclear explosion since explosions are a complex interplay between energy released and time.

Two definitions of a nuclear explosion have been provided for nuclear fission explosions, however. These can begin to form the basis for defining nuclear fusion explosions. The first definition for fission explosions is criticality (or the creation of a self-sustaining chain reaction).

The second definition, suggested by researchers at Los Alamos, is that the energy output of the fission explosion (per gram) is more than the energy of the chemical explosives used for compression.

The concept of ignition in fusion research is analogous to both those definitions of a fission explosion. The first definition of ignition is the creation of a self-propagating burn wave after the initial fusion reactions begin. This is a concept analogous to criticality in fission explosions. The second definition of ignition is that the energy output from the fusion reactions is more than the driver energy output (this is also called a gain of one and establishes the scientific feasibility of these devices). This is a concept analogous to fission explosions releasing more energy than the chemical high explosives used for compression.

For the purposes of CTBT compliance, a minimally satisfactory limit on fusion explosions would be to use the definition of ignition as a gain of one. Under this limit the energy released would always be less than the driver energy input into the fuel pellet since ignition would be prohibited. The conditions for establishing scientific feasibility would also not be achieved. The advantage of this proposal is that it is not limited to any particular technology or an arbitrary yield, but rather is based on a definition of explosions. This limit would therefore ban all ignition experiments such as those to be undertaken at NIF and LMJ. However, any definition of fusion explosions geared to ignition would still allow a considerable loophole for pure fusion weapon development even though the letter of the CTBT would be met. This is because a large number of neutrons per shot can be achieved at gains just under one - that is, just below the ignition threshold. Therefore, other limitations are necessary to prevent the development of pure fusion weapons. They should be implemented. They are discussed in our recommendations.