https://www.globalsecurity.org/wmd/intro/rayleigh-taylor-instability.htm. 2 pages

A general discussion on the progress of Nuclear Weapons

Coupling Thermonuclear devices rely on a two-stage process, in which X-ray radiation from a fission primary is contained and used to trigger a fusion or fusion-fission reaction in a physically separate, secondary portion of the device. The term "interstage coupling" refers to the transfer of energy from the primary to the secondary. Radiation from the fission explosion can be contained and used to transfer energy to compress and ignite the secondary component containing thermonuclear fuel.

The main unknowns to the public are the design of the casing, and the shape and size of the secondary, relative to the primary. Whether the hot plastic does the pushing animist its heat to a designated ablator which does the pushing a matter of continuing public speculation.

The transfer of energy from the primary to the secondary is primarily via radiation in the form of soft X-rays, which travel at light speed. X-rays released by the trigger travel across the gap separating the casing from the trigger, and heat and compress a foam material surrounding the secondary fusion stage. Radiation pressure generated by the X-rays is decoupled from the fluid pressure of the fission fragments, which travel much more slowly

X-ray fluorescence causes the casing ions to generates secondary X-rays. Since the casing atoms have been ionized, when the sea of electrons fall back into their shells, a uniform emission of secondary soft X-rays is released. If the casing is machined just right, it is possible to direct these onto the secondary fuel mass from all directions, leading to a very even compression.

According to one version, the secondary X-rays deposit their energy onto the ablation layer almost instantaneously and uniformly from all sides. The result is instantaneous heating. The surface layer of the fusion target is vaporized, forming a surrounding plasma envelope. The layer undergoes a blow off with great force. This causes the inner part of the wrapper to compress (Newton's 3rd law) due to rocket recoil. This tamper pushes against the secondary Li6D fuel mass, and the mass is compressed to a fraction of its original diameter.

The investigation of radiation transfer and thermonuclear fusion were added to the original list of theoretical issues to be resolved. As bomb design requirements became more demanding and the problems more complex, reliance on numerical solutions by high-speed computer became even more critical. At every stage the stronger the computer, the greater the complexity that could be tackled successfully.

With the postwar responsibility to investigate the feasibility of a two-stage thermonuclear weapon, the fluid dynamics problems became enormously more complicated. The primary and secondary portions of the weapon sit apart from each other. Instead of the simple, single-stage fission-bomb configuration, the dynamics of the separated stages required the analysis of potentially strong distortions of materials moving with incredibly greater complexity. The calculation of non-steady multi-dimensional fluid dynamics became the challenge.

To meet that challenge, the Los Alamos investigators worked with two fundamental viewpoints, Lagrangian (in which volume elements are carried along with the fluid) and Eulerian (in which material flows through volume elements fixed in space), together with various innovative hybrids. First applied to the high-speed flows required in bomb design and weapons-effects analysis, the techniques soon were extended to low-speed (incompressible) flows for wave studies and to the broad field of interpenetrating (multiphase) flows like that of raindrops falling through the air.

Computation of the containment and transfer of radiation in a thermonuclear weapon is a challenge for the most ingenious inventor of computer techniques. Numerical instability manifests itself at first as seemingly benign localized oscillations in, for example, the velocity vectors, but then growing with alarming speed to a catastrophic overflow with numbers exceeding the national debt expressed in pennies. Numerical instability is a chronic threat with a propensity for occurrence in the least expected and most exasperating circumstances.

Plagued by potential numerical instabilities, the accurate calculation requires not only a detailed knowledge of the interaction between radiation and materials, but also a sophisticated around-by-the-back-door type of circuitous mathematical logic for the numerical analysis.

An essential task of the weapons program has always been to determine, with confidence, the performance of nominal, aged and rebuilt stockpile weapons. The secondary stage of stockpile weapons is responsible for much of their yield, so confidence and precision in understanding the factors that control secondary yield is crucial. The related problem of determining the margins and uncertainties associated with understanding secondary performance is a key issue for stockpile stewardship. Secondary certification and nuclear systems margins programs focus on radiation source development, radiation case dynamics studies, radiation transport and the effects of aging and refurbishment on secondary performance.

The Los Alamos Laboratory's case dynamics program seeks to understand the key elements of the sequence of events leading to secondary explosion and weapon performance, and to resolve the physics and computational issues related to them. During the high-explosive phase and subsequent primary explosion, the radiation case is simultaneously subjected to strong shocks, large radiation doses and high pressure, and changes in the case can impact the subsequent radiation flow from the primary to the secondary. Understanding case behavior requires experiments to characterize the materials properties of the radiation case, closely linked to validation modeling and simulation through the Advanced Simulation and Computing program.

In 1993 hydro tests were performed at the PHERMEX radiographic facility to examine radiation case dynamics under high-explosive loading. A low-energy, multi-frame x-ray system was also fielded to provide a second line of sight perpendicular to the PHERMEX beam axis. This x-ray system consists of four x-ray heads (each driven by a 900-kV Marx bank) that share a nearly identical line of sight. The x-ray radiographs were recorded on a CCD coupled to an electronic framing camera that images an LSO (cerium-doped lutetium oxyorthosilicate) scintillator via a 6-mlong optical path. The four x-ray heads were timed to provide images before, between, and after the two PHERMEX radiographs.

All the equipment, with the exception of the camera and Marx banks, was destroyed during experiment due to the proximity to the high explosive charge, end