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LLL Comments on the Ultimate Catastrophe

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LAWRENCE LIVERMORE LABORATORY

[redacted]

December 23, 1975

Dr. F. C. Gilbert
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Washington, D. C. 20545

DECLASSIFICATION STAMP ON REVERSE.

Dear Chuck:

LLL Comments on "The Ultimate Catastrophe"[1]

I will not comment directly on the several pejorative comments made about nuclear energy production and weapons research. Nor will I attempt to clear up Professor Dudley's confusion over variable half-lives, the availability of "aether energy," the earth's gravitational field, or the reproducibility of large-scale physical phenomena. Following are the specific comments:

- The possibility of atmospheric or oceanic burn has been carefully considered several times in the past,[2-4] always with the same conclusion: There is no realistic possibility of any yield enhancement. Higher yield-to-weight weapons in no way change these conclusions.

- The effects of anomalously large cross-sections for nitrogen burning have never been observed in stars, which have the required constituents, high temperatures, and billions of years of reaction time.

- The reaction, $^{14}N + {}^{14}N \rightarrow \alpha + {}^{24}Mg$, was considered to be the most dangerous by Konopinski, et. al.[2] However, the strong electrostatic repulsion of the charged nitrogen ions requires a relative energy of approximately 8.6 MeV for them to approach close enough to fuse. The cross-section for the reactions $^{14}N + {}^{14}N \rightarrow \alpha$, p, or d for energies near this Coulomb barrier have been measured recently.[5] The fall-off in cross section with lower energy agrees well with Gamow theory for barrier penetration. We know of no way to produce temperatures even 10% of those required.

- The cross-sections for the ^{14}N (α,p) and ^{17}O (α,n) reactions in the chain Dr. McNally considers "the most dangerous multiplying chain in air"[6] have also been measured[7-9] and show no resonance higher than 250 mb, more than an order of magnitude too low to sustain any fusion chain reaction, even if sufficient temperatures could be reached.

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- Simple calculations show that the atmosphere is of sufficiently low density that even with enormously high assumed cross-sections, burn proceeds much slower than the processes tending to clamp the matter into a low-temperature equilibrium with its radiation. The available energy per unit volume in air from even complete burnup of the atmospheric nitrogen is only sufficient to produce an equilibrium temperature of less than 1.5 kev, with over 99% of the energy in radiation. Significant burn under these conditions requires initiation by an energy source of many gigatons and also requires the ignoring of a Gamow probability factor of less than 3×10^{-141} for each microscopic interaction!

- Even if nitrogen were many times as reactive as DT, the most reactive known nuclear fuel, the thermonuclear energy generation rate at any plausible temperature would still not suffice to overcome the energy losses due to bremsstrahlung radiation and the inverse Compton effect.

- The fusion chain reactions proposed by McNally fail not only because of the rapid slowing of the suggested chain centers in matter, but also because side reactions absorb these chain centers and prevent any possibility of a chain reaction.

- The physics of thermonuclear burn is a central issue of modern high-yield nuclear weapon design. We have, over the years, assembled a great deal of experimental data and extremely detailed computational models of the processes involved. In view of this information the only method we see of producing fusion energy involves the very light elements--hydrogen, helium, lithium, and possibly boron.

- In response to your inquiry, we have applied modern calculational tools to reexamine in detail the specific problems of thermonuclear burn in the atmosphere and deep under water. We have attained results that are totally negative:

  The calculation of atmospheric burn included both the nitrogen-nitrogen reactions and the chain reactions Dr. McNally considers dangerous. The assumed cross-section for the $^{14}N + ^{14}N$ reactions was a factor of five greater than the geometric cross-section above the Coulomb barrier and was held at 1 barn down to an energy of 5 kev. The cross-section for all other reactions at all energies were conservatively taken to be one to three orders of magnitude greater than the measured cross-sections. There is, therefore, no possibility that the cross-sections in question can exceed these extremely optimistic values. The energy source for the calculation

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was a configuration having a yield-to-weight ratio much higher than we believe possible. This energy source was arbitrarily made to produce 375 Mt in a small fraction of a microsecond. The calculation showed that, as expected, the initial high temperatures in the immediate vicinity of the source quickly abated because of radiation losses. In less than 10^{-5} seconds the atmospheric reactions stopped after producing less than 2.5% of the initial source energy.

The sea was modeled in the most simple yet conservative manner by assuming it was two percent D_2O at high pressure--more than 100 times the actual deuterium concentration. Initial high temperatures near a 500 Mt massless energy source decreased by a factor $\sim$100 in 2×10^{-8} seconds. Subsequent low-order equilibrium fuel burn of the model sea produced an additional 0.006 percent of the source energy before the yield production stopped. The actual deuterium concentration in sea water would have decreased even this minute burn by a factor of approximately 20,000. In fact, propagation failed (by a large margin) in a model sea of <u>pure</u> D_2O under high pressure!

- We have performed detailed chain-reaction calculations[10] in which the reactants, products, and electrons were not constrained to Maxwellian velocity distributions, the kinematics and radiative emission were treated in a relativistically correct fashion. Even at multi-MeV temperatures and assuming the highest physically plausible reaction rates, no divergent chaining effects occurred, the total thermonuclear energy generated fell far below the input energy, and the material was always rapidly cooled by radiation losses in less than 10^{-5} seconds.

In summary, extremely conservative calculations have demonstrated that it is completely impossible for either the earth's atmosphere or sea to sustain fusion reactions of either thermonuclear or nuclear chain reaction type. In particular, such reactions cannot be triggered by the explosion of nuclear weapons, even those having unrealistically high yield and impractically high yield-to-weight.

Sincerely,

Roger

Roger E. Batzel
Director

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