BOOK REVIEW

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Muon-Catalyzed Fusion and Fusion with Polarized Nuclei

Editors	B. Brunelli and G. G. Leotta
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Reviewer	A. A. Harms

Compared to fusion, fission energy production seems so much simpler; all it takes is a critical mass, and the self-regenerated neutrons will sustain an endless sequence of fission reactions.

Recent years have seen a "fission-like" process invading fusion energy research. This is done by directing muons from an accelerator into a chamber containing deuterium and tritium. The muons, possessing one electronic charge and a mass 207 times that of an electron, will readily displace the electron in a hydrogen atom. Further, with its heavier mass, the Bohr orbit of the muon will be 207 closer to the nucleus, making the resultant muonic hydrogen atom appear like an "overweight" neutron. This muonic atom may therefore get closer to the nucleus of another hydrogen atom allowing the nuclear forces of attractions to dominate thereby providing a chance for fusion to occur. Using the symbols d, t, and μ for deuteron, triton, and muon, respectively, the preferred sequence of events is suggested by

$$\mu + t \rightarrow \mu t$$

$$\mu t + d \rightarrow \mu dt$$

$$\mu dt \rightarrow n + a + \mu + 17.6 \text{ MeV}$$

and possesses all the properties of a reaction chain. But, unlike the common $d + t \rightarrow n + a$ process, there is now no need for a plasma, no magnetic field, and no inertial forces; indeed the above sequence of reactions may happen in a glass of water at room temperature if the protonium in H_2O is replaced by deuterium and tritium.

So much for the simplicity of muon-induced fusion—now the (unfortunate) differences. First, the muon is, at best, only recovered and not multiplied; second, the muon has a mean lifetime of 2.2×10^{-6} s and hence needs constant replenishment; third, it costs an average of ~4000 MeV to produce a muon. In short, it becomes necessary for one muon to catalyze some 1000 $d + t$ fusions in its lifetime for a commercial fusion plant to be energetically viable, if only the $d + t$ Q value is recovered and converted.

The theory, experiments, and analysis of the above muon-catalyzed fusion reactions, consisting of 11 papers, are the focus of about two-thirds of this book. Another one-quarter of the book, consisting of seven shorter papers, is concerned with the role of polarized nuclei in fusion reactions; in this latter approach, a fusion reaction rate increase of up to 50% is possible and the unique directional distribution of the reaction products can lead to some interesting reactor design features. In an admitted afterthought, a paper on the "State of the Art and Strategy" of fusion by magnetic confinement has been appended. All 19 papers were presented at the Eighth Course of International Fusion Reaction Technology held April 3-9, 1987, in Erice, Italy. Some 45 scientists, mostly from Western Europe, took part.

Judged as a whole, the papers provide a broadly based and up-to-date description of muon-catalyzed and spin-polarized fusion. The considerable variation of coverage serves to illustrate the range of the subject and caters well to the varied interests of fusion scientists. The organizers are to be congratulated for having brought together some of the leading contemporary "movers" of the subject with but one significant exception: The USSR group (L. Ponomarev, Yu. V. Petrov, and associates), who have consistently pursued muon-catalyzed fusion for the longest time, are noticeable by their absence.

A study of this book illustrates not only some clever approaches and commendable initiatives, but also points to the critical issues of the subject. For muon-catalyzed fusion, it is evidently the muon sticking probability in parasitic captures and ways of reducing this adverse effect; for spin-polarized fusion, it is the production of an adequate beam of polarized nuclei. On the periphery, the perceptive reader will find other novel topics of relevance to fusion among which are advanced fusion fuel cycles, muon-induced triggering of an X-ray laser, fusion-fission hybrids, and accelerator design for muon production.

On balance, one senses the need—if not the expectation—for a quantum jump in muon catalysis and spin polarization. But then, muon-catalyzed fusion researchers have observed such quantum jumps in the past, though Fiorentini's suggested strict numerical regularity (p. 12) is evidently too much to expect for the future. The intellectual vibrancy and subdued optimism one encounters in these papers clearly suggest an exciting opportunity and the need to encourage the unexpected.

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