ABSTRACT

The basic requirements for energy production via controlled thermonuclear fusion are discussed. The application of high peak power laser radiation to this problem is considered. A description of the requirements on radiation wavelength, pulse duration and focused field strength is given with emphasis placed on a controlled fusion reactor configuration providing both ignition and containment properties. Present experimental evidence for laser fusion is reviewed and compared with our theoretical understanding of this approach.
INTRODUCTION

Nuclear fusion fuels such as deuterium and tritium only burn efficiently at temperatures above 40-50 million degrees K. For the past 20 years the generally accepted approach to controlled thermonuclear fusion has centered around efforts to thermally insulate (magnetically confine) such fuels (plasma) from the cold container walls. The task of heating the confined plasma to a sufficiently high temperature so that it will begin to burn slowly has so far eluded solution. Considerable effort has recently been channeled to an alternate approach (inertial confinement) in which long term stable confinement of the hot plasma by magnetic fields is no longer crucial to successful burning.

Before enumerating the fundamental differences in the two approaches, it is instructive to examine the basic criterion that must be satisfied by any thermonuclear fusion reactor. A balance of energy released per fusion reaction \((U)\) against radiation losses \((b)\), and conversion of energy through a thermal cycle to electricity at an efficiency \((\eta)\) is readily formulated. This results in an expression relating the fuel density \((n)\) and the time it is allowed to burn \((\tau)\) to the energy loss and gain variables:

\[
n\tau = \frac{3kT \left( \frac{1}{\eta} - 1 \right)}{\frac{1}{4}\langle\sigma v\rangle U - \left( \frac{1}{\eta} - 1 \right) bT^{1/2}}
\]

\(T\) is the temperature and \(\langle\sigma v\rangle\) is the cross-section for the particular fusion reaction averaged over a Maxwellian velocity distribution. This is the Lawson criterion.\(^1,2\)

The bounds within which any reactor based on the following three reactions will operate is shown in Fig. (1).

\[
\begin{align*}
D + T &\rightarrow \text{He}^4 + n + 17.6 \text{ Mev} \\
D + D &\rightarrow \text{He}^3 + n + 3.25 \text{ Mev} \\
&\quad T + p + 4.0 \text{ Mev}
\end{align*}
\]