

New Nuclear—The Promise of Fusion

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Agenda

- What is nuclear fusion?
- Why is nuclear fusion a desirable energy source?
- Why don't we use fusion energy today?
- When will we be able to produce energy from fusion?

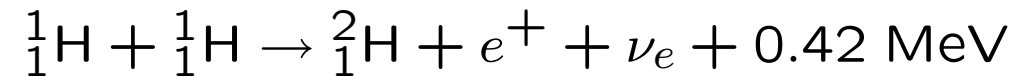
Nuclear Energy

Periodic Table of the Elements

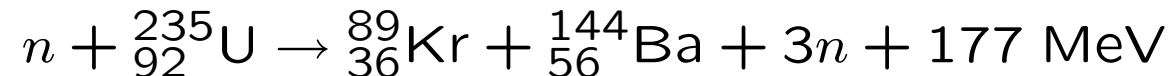
1 H																	2 He														
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne														
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar														
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr														
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe														
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn														
87 Fr	88 Ra	89 Ac	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	110 Uun																						
																		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
																		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

■ hydrogen
■ alkali metals
■ alkali earth metals
■ transition metals
■ poor metals
 nonmetals
■ noble gases
 rare earth metals

- The most stable elements are in mid-table (Iron)
- More stable = Less energy
- Therefore, energy can be released in two ways:
 1. Combining light nuclei to make heavier ones (fusion)



2. Splitting heavy nuclei to make lighter ones (fission)

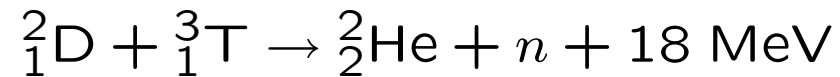


Promise of Fusion Energy

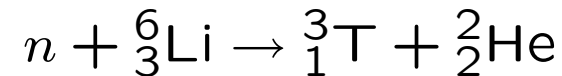
- Fuel is abundant (water)
- Waste products are harmless
- Dangerous accidents are unlikely
- Practically unlimited scaling

Practice

- The only practical reaction is:



with the auxiliary process

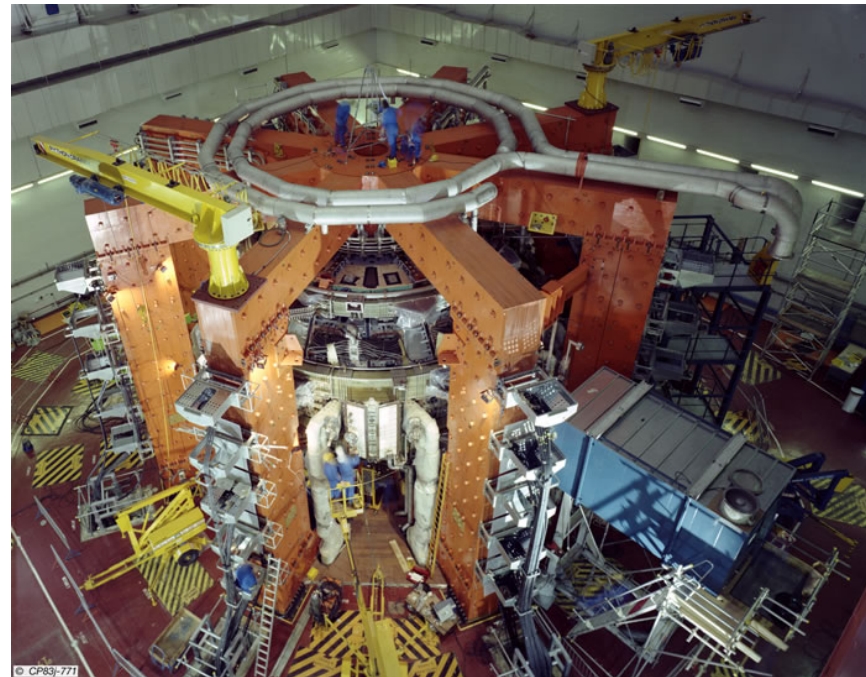
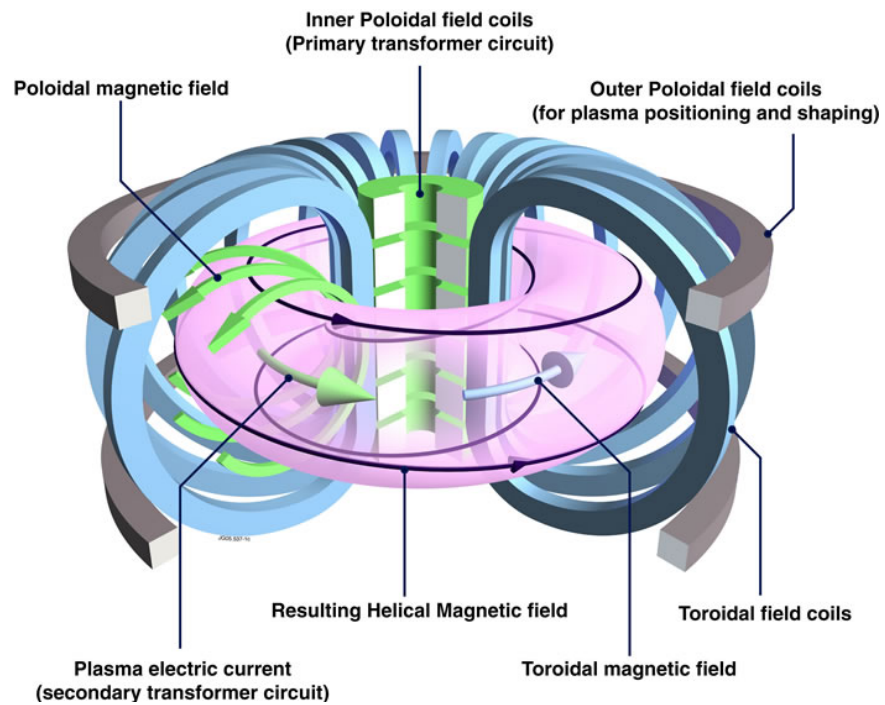


- So the fuels are Li and D
- But small amounts of T must be handled
- And neutrons are a problem

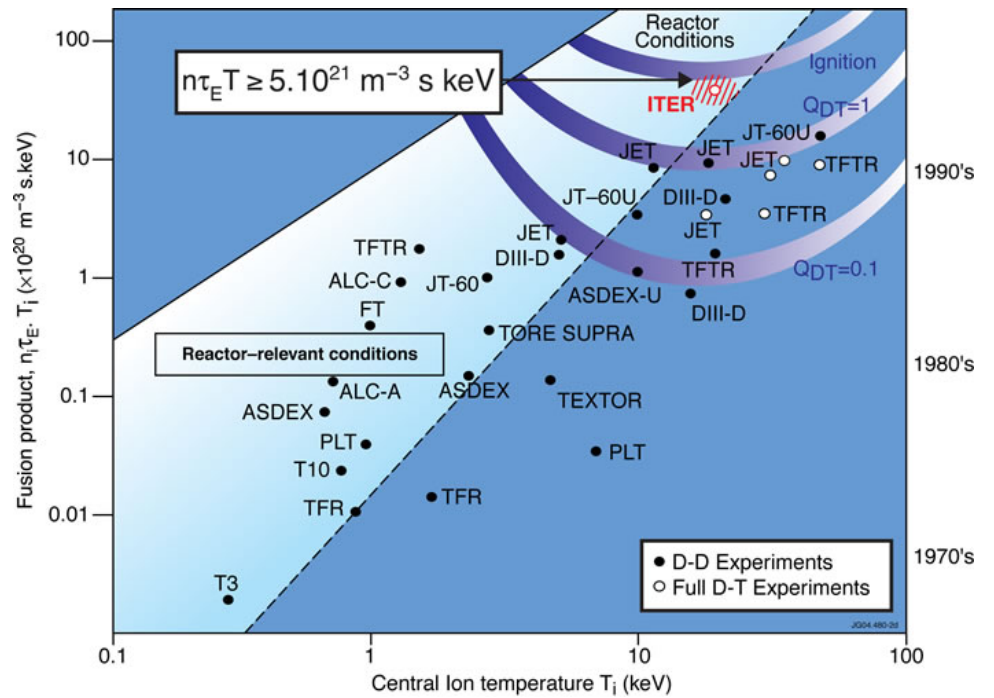
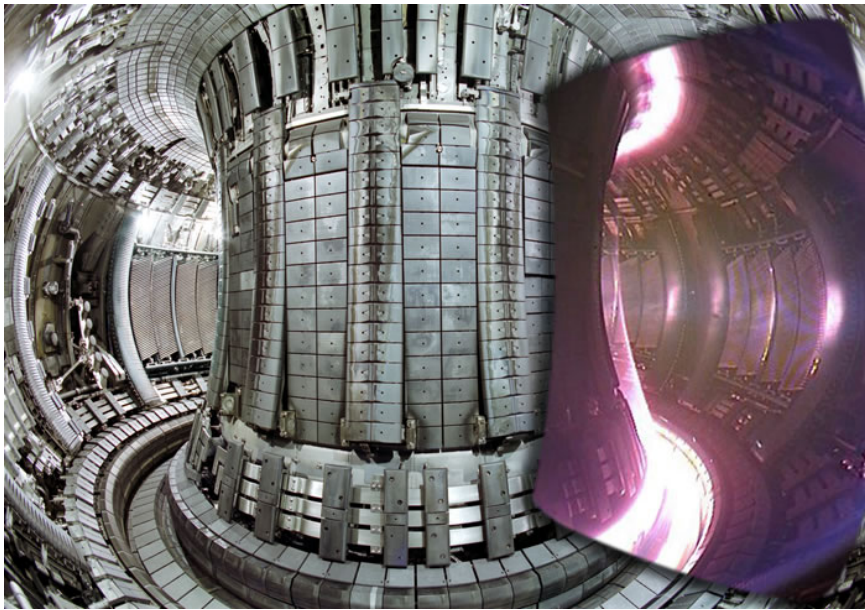
Problems

1. Producing the conditions for fusion (*e.g.* temperature of 10 000 000 K)
2. Tritium management (producing enough to sustain a closed cycle reactor, avoiding accumulation)
3. Avoiding reactor activation (by fast neutrons)

Present Status: Conditions for Fusion



Present Status: Conditions for Fusion

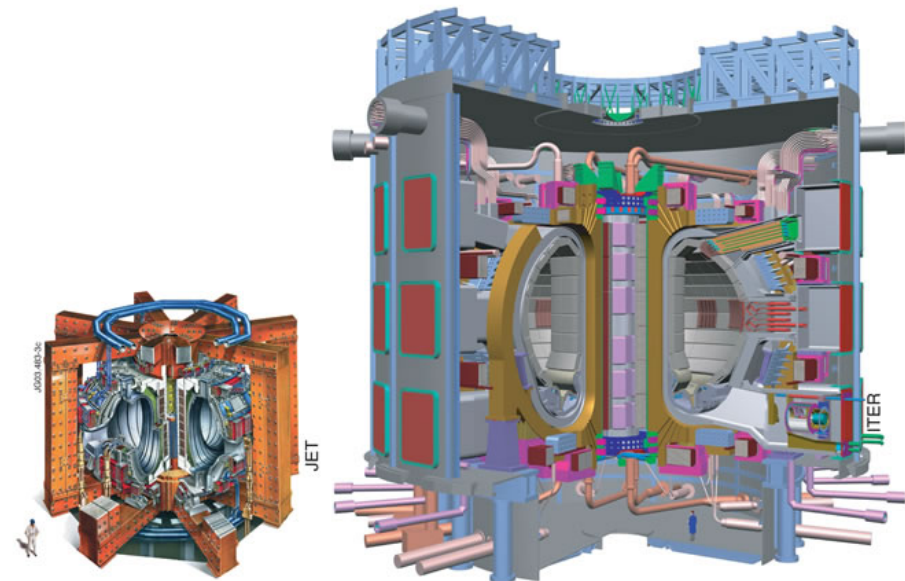


Present Status

- We know how to produce the conditions for fusion
(Relatively modest extrapolation from JET)
- There is a clear concept for closed-cycle tritium management
(Based on experience with JET)
- Work has hardly started on the materials issues
(No relevant experimental facilities)

What next? Iter

- International consortium
- Located in France
- Addressing:
 1. Conditions for fusion
 2. Tritium management
- Operating by 2018



Future Programme

- Iter experimental programme should conclude about 2030
- IFMIF (materials experiment) begins construction (in Japan) shortly
- Iter and IFMIF will inform DEMO (prototype commercial reactor)
- DEMO commissioned about 2040
- Large scale commercial exploitation thereafter

Conclusion

- Fusion energy has compelling advantages
- Technicalities are difficult, but probably surmountable
- Problems:
 1. Final cost is unknown
 2. May be too late (and is difficult to accelerate)
 3. Very complex programme