11 Glossary

Some of the terms used in this report and more generally in the magnetic fusion literature are defined in the Figures and text below. A more detailed explanation of many of the terms can be found in the book *Tokamaks* by John Wesson, Clarendon Press, Oxford, 3rd edition, 2003.

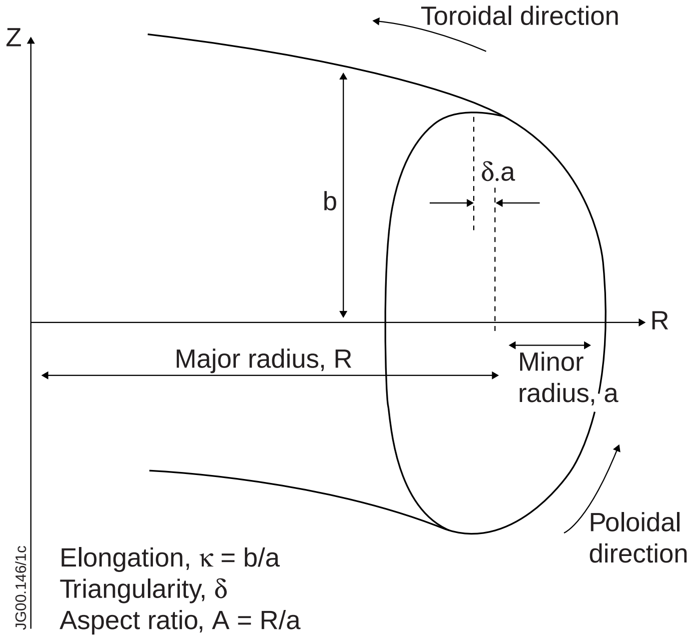

Figure 11.1: *Definitions of terms used to describe the geometry of a tokamak plasma*

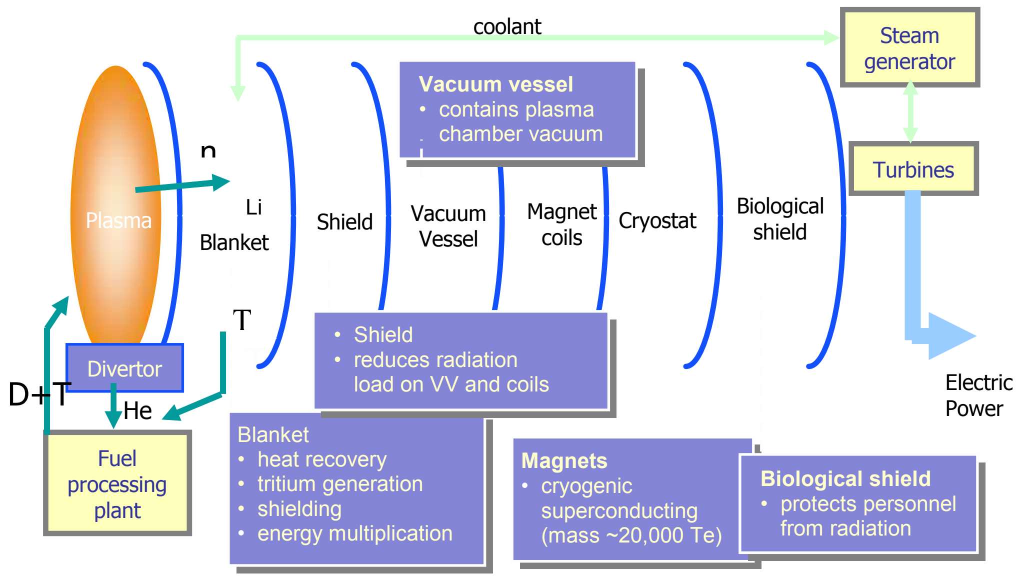

Figure 11.2: *Schematic of a Fusion Power Plant including the production of neutrons (n) and helium (He) by deuterium-tritium fusion reactions in the plasma, and the generation of tritium from reactions between neutrons and lithium (Li) in the blanket. The fusion reaction used in the first fusion power stations will almost certainly be* ***D + T → n + α + 17.6 MeV****, because this requires the lowest temperature*

11 Glossary

Additional heating
Heating in addition to Ohmic heating. Used to heat tokamaks to temperatures at which Ohmic heating is no longer efficient. Usually involves the use of neutral beams of high energy particles or radio-frequency waves.

Advanced regimes
The baseline operating regime for ITER is the ELMy H-mode (q.v.). Advanced regimes represent a step beyond this baseline regime in which the energy confinement is further improved, relative to that expected in H-mode, usually by an Internal Transport Barrier (q.v.). An important characteristic of the advanced regime is that it has a high self-driven (bootstrap, q.v.) current fraction, which minimises the need for expensive external current drive methods, and makes it more suited to continuous operation of a power plant.

Alcator C-Mod
A tokamak at MIT (Boston, USA) with diverted plasmas. One of three major tokamaks in the USA (along with DIII-D and NSTX). Speciality: very high magnetic field, high density, radio-frequency heating.

Alfvén gap modes
The toroidal nature and non-circular cross-section of tokamak plasmas produces gaps in the otherwise continuous spectrum of Alfvén waves, which are populated by discrete, undamped Alfvén gap modes. Under certain conditions these modes can be destabilised by resonant energy transfer from energetic particles (e.g. alpha-particles from fusion reactions) and could lead to enhanced loss of these particles.

Alfvén wave
A fundamental plasma phenomenon, which is primarily magneto-hydrodynamic (*q.v.*) in character: oscillation of the magnetic field and, in some cases, plasma pressure. In tokamaks, these waves are typically strongly damped (i.e. they would spontaneously decay if externally excited). See also fast Alfvén wave.

Alfvén velocity
The velocity of propagation of Alfvén waves in the direction of the magnetic field; it is proportional to the magnetic field strength, and inversely proportional to the square root of the ion mass density.

Alpha-particle (α-particle)
The nucleus of a helium atom, consisting of two protons and two neutrons bound together. In a fusion power plant, energetic alpha-particles (as well as neutrons) will be created by the fusing of deuterium and tritium nuclei. The plasma heating which is provided by these alpha-particles as they slow down due to collisions will be essential in achieving ignition: this heating was demonstrated in a 1997 JET experimental campaign in which tritium fuel was used (DTE1).

Analytic/Computational modelling
Analytic: algebraic solution of mathematical equations describing a physical situation.
Computational: numerical solution of equations using a computer.

Anomalous transport
The measured heat and particle loss (or ‘transport’) in a toroidal plasma is usually anomalously large compared to that predicted by the basic theory of heat transport due to collisions (i.e. ‘neo-classical’ theory, which neglects plasma turbulence).

Armour materials
The first wall of a reacting fusion device, facing the plasma, is subjected to a surface flux of particles and heat in addition to the volume effect of irradiation damage (*q.v.*). Of the four candidate materials (beryllium, carbon, molybdenum and tungsten) tungsten holds the best long-term promise.

ASDEX-Upgrade
The major tokamak in Germany, sited at Garching. It is intermediate in size between COMPASS-D and JET, and has the same magnetic configuration as these devices and as that planned for ITER.

Aspect ratio
Ratio of major to minor radius of the toroidal plasma (see Fig 11.1); on JET and COMPASS-D, the aspect ratio is approximately 3 (as planned for ITER): START could operate as low as 1.2 and MAST down to 1.3.

Associations
The 'national' fusion programmes across Europe are all co-ordinated within the EURATOM fusion programme through a system of Associations including the EURATOM/UKAEA Association. The Contracts of Association (e.g. the EURATOM/UKAEA CoA) and EFDA are the mechanisms for EURATOM part-funding of the EURATOM/UKAEA fusion programme, which is presently 20% for most expenditure and 40% for certain items. The remaining funding is from the national government; in the case of the UK, this comes from the Engineering and Physical Sciences Research Council (EPSRC).

Austenitic stainless steel
Non-magnetic alloys based on the Fe-Ni-Cr system and having more than 16% Cr. Corrosion-resistant high temperature types containing molybdenum, exemplified by type 316L, are the structural material chosen for ITER, because their properties are sufficiently well-qualified to be used in current designs. However, the embrittlement of austenitic steels under irradiation precludes their use for future fusion power plants.

Auxiliary heating - Same as additional heating.

Ballooning instability
A localised instability which can develop on the outboard side of the tokamak plasma when the plasma pressure exceeds a critical value; it therefore constrains the maximum β (*q.v.*) that can be achieved. It is analogous to the unstable bulge that develops on an over-inflated pneumatic inner tube.

Banana orbits - See trapped particles.

Beryllium
A light metal that could be used in a fusion power station both as a plasma-facing material and in the blanket as a multiplier of neutrons (which I required to produce enough tritium).

Beta (β), Beta-poloidal
Ratio of plasma pressure to total magnetic field pressure (in Beta-poloidal it is only the pressure of the poloidal magnetic field). One of the figures of merit for magnetic confinement (): the magnitude of the magnetic field pressure determines the expenditure on the field coils, etc., that generate it; since fusion reactivity increases approximately as the square of the plasma pressure, a high value of beta is an indicator of good performance. The highest volume-averaged beta yet attained in a tokamak is ~40%. This figure, reached in the Culham spherical tokamak START, is more than three times that achieved on any conventional tokamak.

Beta-normalised (β_N)
The ratio of plasma current (in MA) to the product of minor radius (in m) and magnetic field (in T) characterises the limit to the achievable β imposed by ideal MHD (*q.v.*); beta-normalised is the ratio of β (expressed as a percentage) to this parameter. Generally $\beta_N = 3$ should be achievable, but techniques for obtaining higher values have been proposed and observed experimentally. Values of $\beta_N \sim 5.6$ were achieved in START and, more recently, MAST.

Blanket
In a fusion power plant, the system surrounding the plasma used to slow down the neutrons produced, so that the heat released can be used for electricity generation. The blanket is also used to synthesise tritium (from the neutrons and a lithium compound) to use as fuel.

Bootstrap current
A theory developed by UKAEA scientists in 1970 predicted that a toroidal electric current will flow in a tokamak which is fuelled by energy and particle sources that replace diffusive losses. This diffusion-driven bootstrap current, which is proportional to β and flows even in the absence of an applied voltage, could be used to provide the confining magnetic field: hence the concept of a bootstrap tokamak, which has no toroidal voltage. A bootstrap current consistent with theory was observed many years later on JET (*q.v.*) and TFTR (*q.v.*); it now plays a role in the design of experiments and power plants (especially steady state tokamaks).

Break-even
The fusion performance of a power plant is measured by Q, the ratio of the power in fusion products to that used to heat the plasma. Break-even corresponds to Q=1, while ignition corresponds to infinite Q. A burning plasma has Q > 5. Q > 15 would be needed in a power station.

Breeder
A term sometimes used to indicate the component of a fusion power plant used to 'breed' tritium from fusion neutrons, for use as fuel in the power plant. There is no relationship to the breeding process in fast reactors.

Broader Approach
The name given to the joint fusion projects agreed by Europe and Japan at the time that the ITER site decision was made.

Burn - See Break-even

Campaigns (JET) - See S/T Tasks

CCD
Charge-coupled device. A very sensitive electronic method of detecting light, used in large arrays for spectroscopy, and visible/infra-red cameras.

CCE-FU
Europe's senior fusion committee: Consultative Committee for the EURATOM Specific Research and Training Programme in the Field of Nuclear Energy (Fusion).

C-DN - See single/double null.

Centre post
A current-carrying central rod placed down the symmetry axis of a spherical tokamak to produce the toroidal field. This is a crucial component determining the economics of fusion power from spherical tokamaks.

CEUSC
Culham-EURATOM Steering Committee of the EURATOM/UKAEA Association.

Charge exchange
Process whereby an ion gains an electron from an atom. If the initial ion is hydrogenic (i.e. if it has one proton), it is neutralised, ceases to be confined by the magnetic field and is lost from the plasma. The ion energies and hence the plasma temperature can be deduced with a neutral particle analyser.

Charge exchange recombination spectroscopy (CXRS)
Atoms in the plasma (from, for example, a neutral beam) donate electrons to fully ionised impurity ions, producing hydrogen-like ions. As the electrons decay from excited states they emit photons from which impurity temperatures, rotation, and density can be measured using conventional spectroscopy.

Close Support Unit (CSU)
The EFDA (*q.v.*) Leader is based at Garching (Germany) and the JET Associate Leader at Culham. There are Garching and Culham EFDA CSUs to assist them, and a CSU in Barcelona was established as a forerunner to the European Domestic Agency (*q.v.*) responsible for Europe's ITER procurements.

CoA
Contract of Association, e.g. between UKAEA and EURATOM.

Collisionality
A measure of how frequently collisions occur in a tokamak plasma. A collisionality of unity corresponds to a trapped particle performing a single banana orbit before being scattered. The collisionality drops as the plasma temperature rises.

COMPASS(-C)(-D)
Compact Assembly: the Culham conventional tokamak facility. COMPASS-C (with circular vacuum vessel) operated from 1989-91; COMPASS-D (with D-shaped vacuum vessel) operated until March 2001. COMPASS-D has a magnetic geometry similar to that of JET and therefore has played an important role in scaling experimental results through JET to ITER. It has been now been transferred to Prague, for experiments by the Czech Association.

Component Test Facility (CTF)
A compact fusion device, perhaps based on the Spherical Tokamak, that might be used to test the performance of power station components in large fluences of neutrons from fusion reactions, as well as other aspects of a power station environment (thermal and mechanical stresses, etc.).

Confinement - See plasma confinement.

Confinement time
The average time taken for energy or particles to leave the plasma.

Creep
Dimensional changes occurring in a structural material in the presence of an applied stress. Creep is enhanced in materials subjected to irradiation damage *(q.v.).*

Cryostat
A few existing experiments, ITER, and fusion power plants employ or will employ superconducting coils (*q.v.*) rather than the conventional magnets usually encountered in present-day devices. The cryostat is the device that isolates these coils thermodynamically, thus permitting operation at temperatures close to absolute zero without excessive cooling requirements.

CSU - See Close Support Unit

CTF - See Component Test Facility

Current distribution
The variation of plasma current density within the plasma, usually expressed as a function of the distance from the magnetic axis.

Current drive (non-inductive)
A method of driving plasma current that does not depend on transformer action (e.g. by using RF waves or neutral beams); necessary for a continuously operated power plant, since transformer action is cyclic. Also applied to control instabilities and to optimise confinement.

Current profile - same as Current Distribution

Current ramp-up (down)
The increase (decrease) of plasma current either at the start of operation (ramp-up) or during operation to modify the current profile for performance investigations.

CXRS - See Charge exchange recombination spectroscopy

Cyclotron frequency
Charged particles in a magnetic field have a natural frequency of gyration in the plane perpendicular to the magnetic field - the cyclotron frequency. For electrons in a tokamak, the cyclotron frequency is typically a few tens of GHz, and for ions, a few tens of MHz.

Cylindrical approximation
An approximation to the true tokamak geometry in which the torus is cut and straightened, so that the toroidal direction becomes the cylinder axis. There are two directions of symmetry: along the axis (the ‘toroidal’ direction) and about the axis (the ‘poloidal’ direction).

DBTT
As a material is cooled a temperature is reached at which it loses its ductile properties and becomes brittle. This ductile-to-brittle transition temperature (DBTT) is a key factor in the development of fusion structural materials because its value increases under irradiation. The development of steels that retain a DBTT below the lowest working temperature encountered during operational shutdowns is a major materials objective.

Deuterium - helium-3 reaction
An alternative fusion reaction to the deuterium-tritium reaction:-

$$D + {}^{3}He \rightarrow p + \alpha + 18.4\ \text{MeV}$$

Since the fuel is not radioactive and relatively few neutrons are produced (from subsequent reactions between daughter products), this reaction has safety and environmental advantages over the deuterium-tritium reaction. However, it is harder to achieve, with higher temperatures, densities and confinement times required for power plant operation.

D-T
Deuterium-tritium mix plasma: D-T is the most likely fusion reaction to be used in future fusion power plants as it occurs at the lowest temperatures. D-T fuel has been used in both JET and TFTR. The reaction releases a neutron, an alpha-particle (i.e. helium nucleus) and energy:

$$D + T \rightarrow n + \alpha + 17.6\ \text{MeV}$$

DEMO
Demonstration power plant envisaged to follow ITER. In the 'fast track' (*q.v.*) route to fusion power, the earlier qualification of material properties (in parallel with ITER operation) would mean that DEMO could be a prototype power plant.

Density functional theory
Density functional theory is a successful approach for describing the ground state properties of metals, semiconductors, and insulators, for both standard bulk materials and more complex materials. The interacting system of electrons is described via its density and not via its many-body wave function. For N electrons in a solid this means that the basic variable of the system depends only on the three spatial coordinates, rather than 3N degrees of freedom.

Detached plasma
A plasma from which there are strong radiative losses, reducing the power flowing to material surfaces nearly to zero. An important feature in divertor design.

Detritiation
The removal of tritium from materials, either in situ in a fusion device or externally.

Deuterium
A stable isotope of hydrogen, whose nucleus contains one proton and one neutron. Deuterium plasmas are used routinely in present-day experiments; in a fusion power plant the plasma will consist of a mixture of deuterium and tritium which fuse more readily than two deuterium nuclei.

Diagnostic
Apparatus used for measuring one or more plasma quantities (temperature, density, current, etc.).

Diffusion, thermal (or particle)
The flow of heat (or particles) down a thermal (or density) gradient.

DIII-D
The major ITER-shaped US tokamak, run by General Atomics, San Diego. It is of similar size and shape to ASDEX-Upgrade.

Disruption, Disruptive instability
A complex phenomenon involving MHD instability which results in rapid heat loss and termination of a discharge. Plasma control may be lost, triggering a VDE (*q.v.*) in which the apparatus may be damaged, particularly in large machines. This phenomenon places a limit on the maximum density, pressure and current in a tokamak.

Distribution function
Function describing the variation of particle number density in both velocity and space.

Divertor
A magnetic field configuration affecting the edge of the confinement region, designed to divert impurities/helium ash to a target chamber (this chamber is also often called the "divertor"). Alternative to using a limiter to define the plasma edge.

Domestic Agencies
Most of the ITER components are being provided ‘in kind’ by the seven ITER parties, each having its own Domestic Agency for this purpose. Europe’s is in Barcelona; the European Joint Undertaking for ITER and the Development of Fusion Energy, also known as 'Fusion for Energy' of ‘F4E’.

Double null - See single/double null.

Dpa
In irradiation damage *(q.v.)* the conventional unit of fluence (*q.v.*) is the dpa (displacements per atom). This measure of damage is a calculated value, derived from neutron transport calculations and a model of scattering recoils. Proposed fusion structural materials may be able to withstand about 100 dpa over their lifetime. Although this value literally implies that each atom is displaced from its lattice site one hundred times on average, the rapid return of nearly all of the interstitial atoms to vacant sites results in a low number of Frenkel pairs (displacement-vacancy pairs) at any given time.

Drift orbits
Apart from gyration around the magnetic field, particle motion is mainly in the direction of the field, but, particularly for fast particles, electric fields and gradients of the magnetic field give an additional drift perpendicular to the magnetic field. The path of the centre of gyration is the drift orbit.

Driven current
Plasma current produced by a means external to the plasma (e.g. a transformer, neutral beams, RF waves).

DTE1
JET experimental campaign using tritium as well as deuterium to enhance fusion reactivity. DTE1 occurred in 1997. The maximum power (~16 MW) and energy (~21 MJ) produced from fusion reactions were both world records, which still stand.

EAST
A long pulse superconducting tokamak in China that first operated in 2006.

ECCD
Electron cyclotron current drive. Non-inductive current drive using ECRH.

ECE
Electron cyclotron emission. Radiation emitted by electrons as a result of their cyclotron motion around magnetic field lines. Used to measure electron temperature.

ECR(H)
Electron cyclotron resonant (heating) – the use of radio-frequency waves to accelerate electrons gyrating in the magnetic field. Used on COMPASS-D, MAST and several other devices.

EDA
Engineering Design Activities of ITER, 1992-1998, culminating in the Final Design Report (FDR). A three year extension, which ended in July 2001, was agreed by Europe, Japan and the Russian Federation, but the USA reduced its involvement and then withdrew in July 1999 (the USA re-joined ITER in February 2003).

EFDA
The European Fusion Development Agreement is the umbrella agreement that has allowed operation of the JET facilities since January 2000 (see JET Implementing Agreement). Until 2006 it also covered technology activities in the European programme (including participation in ITER), but most of this responsibility is passing to the European Domestic Agency (*q.v.*) and instead EFDA is playing a much increased role in co-ordinating fusion physics across Europe.

Electron Bernstein Wave
A wave that only exists in a hot plasma, is supported by electron motion, and propagates at frequencies close to harmonics of the electron cyclotron frequency, also exist. It is a promising candidate for heating spherical tokamak plasmas, as it does not have a density limit; most other RF waves can only propagate at relatively low density in the low magnetic field of the ST.

Electron temperature
A measure of electron thermal energy in units of degrees or electron volts (1 eV ~ 10^4 degrees Celsius).

Elongation (κ)
The ratio of the plasma height to its width (see Fig 11.1).

ELM
Edge localised mode. An instability that often occurs in short periodic bursts during H-mode in divertor tokamaks. It causes transient heat and particle loss into the divertor which can be damaging. Small ELMs are useful for impurity/density control.

ELMy H-mode
A frequently-observed type of H-mode in which ELMs occur continuously. This is the baseline operating scenario for ITER.

Embrittlement
Reduction of impact toughness in a structural material. Contributing causes are low temperature, the presence of hydrogen, and - of particular significance in fusion materials - irradiation damage.

Energetic particle
In terms of energy, the particles in a plasma can be divided into two classes. The more numerous class (thermal particles) consists of particles whose distribution in energy can be characterised by a temperature typically in the range 1-30 keV for modern tokamaks. The less numerous class (energetic particles) contains particles of significantly higher energy (up to several MeV). Energetic particles can be created by fusion reactions, introduced into the plasma by neutral beam injection, or accelerated *in situ* by radio-frequency waves.

EP1, EP2
Major JET Enhancement Programmes undertaken since EFDA assumed responsibility for JET in 2000. Each has a wide range of enhancements; in EP1, which is now essentially complete, the largest enhancement was a new ITER-like ICRF antenna. In EP2, which is ongoing, the two biggest changes are a new ITER-like plasma-facing wall made of beryllium with a tungsten divertor, and a major upgrade to the neutral beam heating system.

EPSRC
The Engineering and Physical Sciences Research Council. This organisation has funding responsibility for the UK fusion research programme.

Error fields
The magnetic coils of a tokamak are designed to give the desired magnetic field configuration. Inevitably, however, imperfections in their construction lead to unwanted deviations from this configuration known as error fields. These can lead to disruptions and are of particular concern for larger tokamaks.

EURATOM
European Atomic Energy Community

EVEDA
Engineering Validation and Engineering Design Activity for IFMIF (*q.v.*).

External costs
The indirect costs of power stations, associated with environmental damage or adverse impacts upon health: for fusion these are very small.

F4E
See Domestic Agencies

Fast Alfvén wave
The fast Alfvén wave (often referred to simply as the fast wave) exists over a broad frequency spectrum, from the ion cyclotron range of frequencies (ICRF) where its character is electromagnetic, down to MHD frequencies. Its velocity is comparable to the Alfvén velocity. The fast Alfvén wave is used routinely for high-power (~20 MW) ICRF heating on JET, as it is efficiently absorbed in the plasma via the mechanism of ion cyclotron resonance. Although usually stable in tokamaks, the wave can be excited by energetic ion populations.

Fast igniter
A two-stage approach to inertial fusion in which compression of the fuel by a driver is followed by a separate, ignition pulse (perhaps using a different driver).

Fast track
A proposed route to fusion power in which the physics and technology of burning plasmas (ITER) is developed in parallel with the testing of materials under the sustained neutron fluxes of a power plant (IFMIF).

Fast wave current drive
Current drive produced by a fast wave, as opposed to a lower hybrid wave. The wave can penetrate the plasma more easily than a lower hybrid wave. ICRF systems can produce fast waves.

Feedback
Use of measurements of parameters together with power supplies to change the control or heating of the plasma to maintain desired conditions.

Ferritic-martensitic steels
Magnetic alloys which, when modified to improve their ductility, represent the most promising structural material for the first generation of fusion power stations. In microscopic terms they have a body centred cubic lattice structure; such structures are thought to have the highest resistance to embrittlement (*q.v.*) under irradiation.

Field lines, Flux surfaces
Field lines are imaginary lines marking the direction of a magnetic field. In a tokamak plasma these define a set of nested toroidal surfaces, to which particles are approximately constrained, known as flux surfaces.

FIR
Far infra-red (wavelength ~ 0.2 to 1 mm). FIR lasers are used to measure the magnetic field (by Faraday rotation) and plasma density.

Flat-top (current)
The steady period of a plasma discharge (and the value of plasma current).

Fluence
Time-integrated power density (*q.v.*). The neutron fluence in a fusion power plant is measured in MW yr m^{-2}.

Fokker-Planck code
A computer code used to calculate the velocity distribution of plasma particles, allowing for collisional relaxation and plasma heating. Calculates distribution functions (*q.v.*).

FTU
A high magnetic field tokamak located at Frascati, Italy.

Fusion for Energy (also known as F4E)
See Domestic Agencies

Fusion product
Particle produced in a fusion reaction, for example an alpha-particle or neutron in a deuterium-tritium plasma.

Fusion reactivity
Fusion reaction rate per ion. For present typical tokamak conditions, it increases with the density and temperature of the plasma.

Fusion triple product
The result of multiplying density, temperature and energy confinement time. A measure of proximity to energy break-even and ignition.

GLOBUS-M
A spherical tokamak at the Ioffe Institute, St Petersburg, Russia, of comparable size to START.

Greenwald limit/density
An empirical limit to the operational density in a tokamak. It can be exceeded (e.g. by pellet injection on START and MAST) but requires more understanding as ITER is expected to operate close to this limit.

Gyro-kinetic theory
Version of kinetic theory in which the Larmor radius is not assumed to be small. An essential theory for investigating fine-scale instabilities that might be responsible for driving turbulence: this may in turn be the cause of anomalous transport.

Gyro-radius - same as Larmor radius (*q.v.*)

Gyrotron
Device used for generating high power microwaves in the electron cyclotron range of frequencies ($\approx$ 30 - 200 GHz).

H-L transition
Change from H-mode to L-mode (usually quite sudden).

H-mode (regime)
A high confinement regime that has been observed in tokamak plasmas. It develops when the plasma is heated above a characteristic power threshold, which varies with density, magnetic field and machine size. The H-mode is characterised by a sharp temperature gradient near the edge (resulting in an edge 'temperature pedestal') and typically a doubling of the energy confinement time compared to the normal L-mode. ELMs (*q.v.*) are often observed in this regime.

Halo currents
Currents which flow outside closed magnetic surfaces, through plasma-facing components, usually during VDEs (*q.v.*). The resultant forces can be large.

Helias
A stellarator configuration in which the coils resemble distorted, non-planar toroidal field coils - no continuous helical coils or tokamak-like poloidal field coils are present. The Helias (HELIcal Advanced Stellarator) has been proposed as the most promising stellarator concept for a power plant, with a modular engineering design and optimised plasma, MHD and magnetic field properties. The WENDELSTEIN 7-X device (*q.v.*) is based on a five field-period Helias configuration.

Heliotron
A stellarator configuration in which a helical coil is used to confine the plasma, together with a pair of poloidal field coils to provide a vertical field. Toroidal field coils are sometimes also used to control the magnetic surface characteristics.

Helium ash
Fusion reactions in a deuterium-tritium plasma produce energetic alpha-particles (helium nuclei), which heat the plasma as they slow down. Once this has happened, the alpha-particles have no further use: they constitute helium ash, which dilutes the fuel and must be removed to maintain a burning plasma.

High beta (β)
Condition in which the plasma energy is a significant fraction of the energy in the magnetic field. Alternatively, a condition in which the plasma energy is comparable to the energy in the poloidal magnetic field (i.e. poloidal $\beta \sim 1$).

IAEA, IEA
International Atomic Energy Agency, based in Vienna.
International Energy Agency, based in Paris.

ICRF
Ion cyclotron range of frequencies (~20-50 MHz).

ICRH
Ion cyclotron resonance heating. An additional heating method using ICRF waves whose frequency matches that at which ions gyrate around the magnetic field lines.

Ideal MHD
In the context of MHD, 'ideal' implies that the magnetic field and the plasma always move together. For this to occur, the effect of electrical plasma resistivity must be negligible.

Ideal internal kink modes
An MHD instability of the central region of a tokamak. This, or its close relative the resistive internal kink mode, may be involved in 'sawtooth' oscillations (*q.v.*) which occur in most tokamaks.

IFMIF
The International Fusion Materials Irradiation Facility (IFMIF) is a proposed device that would test the structural integrity of fusion power plant materials under appropriate irradiation damage (*q.v.*) conditions. The detailed design and prototyping are being undertaken by Europe and Japan as a Broader Approach (*q.v.*) project.

Ignition condition
Condition for self-sustaining fusion reactions: heat from fusion alpha-particles = heat loss.

Impurities
Ions other than fuel ions. Unwanted since they cause a loss of energy by radiation and dilute the plasma.

Impurity screening
The prevention of impurities from entering the plasma.

Inertial fusion
An approach to controlled fusion in which laser or particle beams are used to compress and heat fuel pellets. So-called because it is the inertia of the fuel ions that allows the pellet to remain compressed for long enough for fusion to occur.

Internal costs
The conventional costs arising from constructing, operating, maintaining and decommissioning power stations. See external costs.

Internal reconnection event (IRE)
An instability that breaks magnetic field lines and reconnects them with a different topology, thereby reducing the system to a lower energy state - associated with the operating limits of spherical tokamaks.

Internal transport barrier (ITB)
See transport barrier: 'internal' indicates that the transport barrier is created in the plasma core, not at the plasma edge.

Inversion radius
When a sawtooth crash (*q.v.*) occurs, soft X-ray emission from the plasma core falls, while emission from the outer region of the plasma rises. The inversion radius is the distance from the plasma centre at which the emission remains constant.

Ion cyclotron current drive (ICCD)
Non-inductive current drive using ICRH.

Ion cyclotron resonance heating, Ion cyclotron range of frequencies - See ICRH and ICRF.

IR
Infra-red part of the electromagnetic spectrum.

IRE - same as Internal Reconnection Event.

Irradiation damage
The effect of irradiation on the lattice structure, and hence on the mechanical properties, of materials. The 14 MeV neutrons produced by the deuterium-tritium fusion reaction are slowed down and absorbed by the materials surrounding the plasma. This neutron scattering transfers energy to individual atoms within the lattice, ejecting them from their original locations (Primary Knock-on Atom – PKA) with sufficient energy to initiate displacement cascades. This phenomenon of displacement damage is well-known in fission. Additionally the neutrons induce transmutation reactions, of which the most significant products are helium and hydrogen. This latter phenomenon differentiates damage in fusion from that in fission. See dpa.

ITER
International Tokamak Experimental Reactor. A project originally funded by four parties (EU, USA, Japan, the Russian Federation) to design and possibly construct a sustained burning tokamak plasma for physics and technological demonstration of fusion power. When the Engineering Design Activities were extended by three years in 1998, the USA reduced its involvement and then withdrew, and the focus shifted to a design with reduced technical objectives and therefore reduced cost. This design is defined in an Outline Design Report, published in 1999, and a Final Design Report, issued in 2001. After July 2001, ITER was forward under a programme of Co-ordinated Technical Activities and ITER Transitional Arrangements, also under IAEA auspices. In 2003 the USA re-joined the project, and China and South Korea also joined. In June 2005, the six parties decided to build ITER in Cadarache in France. India later joined. The international treaty was signed in November 2006 and the central organisation established in Cadarache. Most of the components will be provided by Agencies set up for this purpose in the seven partners (see Domestic Agencies).

ITPA
International Tokamak Physics Activity, set up in October 2001, co-ordinates experiments on and analysis of data from the world's tokamaks, with a view to providing the best physics basis for ITER (and other burning plasma experiments).

JANNUS
The collective name of two multi-ion-beam facilities for materials experiments in France, which will be available for fusion materials modelling validation and other tests. They are designed to simulate neutron damage processes by subjecting thin films of materials simultaneously to bombardment by heavy ions and implantation of helium and/or hydrogen. There will be In-situ transmission electron microscopy and other diagnostic devices.

JET
Joint European Torus, sited at Culham. One of the world's two largest tokamaks, capable of mimicking the geometry of ITER, and associated facilities such as the power supplies and tritium plant. Exploitation of the JET facilities was by a separate legal entity, the JET Joint Undertaking, until this terminated on 31 December 1999 and new arrangements came into force (see JET Implementing Agreement).

JET Implementing Agreement, JET Operation Contract
The Agreement within EFDA (*q.v.*) that has allowed operation of the JET facilities after the JET Joint Undertaking expired on 31 December 1999. EURATOM has a contract (the JET Operation Contract) with UKAEA, which operates the facilities for a collective European programme of science and technology experiments. These experiments are undertaken by scientists from laboratories across Europe (and beyond) organised in Task Forces (see S/T Tasks).

JET Joint Undertaking - See JET.

JT-60SA
A new superconducting tokamak, to be built at Naka in Japan as part of the Broader Approach (*q.v.*) agreement between Europe and Japan.

JT-60U
A JET-scale tokamak, sited in Naka, Japan, but not having some of the facilities available on JET (especially tritium capability).

Kinetic theory
A detailed mathematical model of a plasma in which trajectories of constituent electrons and ions are described. More complex than single-fluid and two-fluid theories, it is necessary in the study of RF heating and some instabilities, particularly when small spatial scales and/or energetic particles are involved.

Klystron
A source of microwave radiation incorporating an electron beam in a magnetic field. Used mostly for lower hybrid wave systems.

KSTAR
A long pulse superconducting tokamak being constructed in South Korea.

LHD
Large Helical Device: a large superconducting stellarator in Japan which first operated in 1998.

L-H transition
Change from L-mode to H-mode (usually quite sudden).

L-mode (regime)
The low confinement regime of additionally-heated tokamak operation (cf. H-mode, *q.v.*).

Langmuir probe
Electrical probe inserted into the edge of a plasma for measurements of density, temperature and electric potential.

Larmor radius
Radius of the gyratory motion of particles around magnetic field lines (see cyclotron frequency).

LIDAR - See Thomson Scattering.

Limiter
A material surface within the tokamak vessel which defines the edge of the plasma and thus prevents contact between the plasma and the vessel. Alternative to using a divertor to define the edge.

Locked modes
MHD modes that cease rotating (although they can still grow).

Low activation materials (LAM)
Optimisation of the chemical composition of materials can significantly reduce their radio-activation following neutron bombardment in a fusion device. It is important to reduce long-term activation to facilitate the recycling or disposal of materials. Sometimes the terms RAM (reduced activation materials) and RAFM (reduced activation ferritic-martensitic) steels may be encountered.

Lower hybrid current drive (LHCD)
Non-inductive current drive using lower hybrid waves. Used on JET and several other devices.

Lower hybrid (LH) wave
A plasma wave of frequency between the ion and electron cyclotron frequencies. It has a component of electric field parallel to the magnetic field, and can thus accelerate electrons along field lines.

Magnetic axis
The magnetic surfaces of a tokamak form a series of nested tori, with different minor radii. The central 'torus', of zero minor radius, defines the magnetic axis.

Magnetic islands
Helical structures in the magnetic field caused either by externally-applied helical fields or internally by unstable current or pressure gradients. See tearing magnetic islands.

Magnetohydrodynamics - See MHD.

Major radius
The distance from the tokamak symmetry axis to the geometric centre of the plasma (Fig 11.1).

MARFE
Multifaceted Asymmetric Radiation From the Edge. A thermal instability sometimes observed near the edge of tokamak plasmas at high density.

Marginal stability
A state in which a plasma is close to the transition between stability and instability.

MAST
Mega Amp Spherical Tokamak at Culham, twice as large (in linear dimensions) as its predecessor, START (*q.v.*). Experiments started in December 1999.

MHD (Magnetohydrodynamics)
A mathematical description of the plasma and magnetic field, which treats the plasma as an electrically conducting fluid. Often used to describe the bulk, relatively large-scale, properties of a plasma.

MHD Instabilities
Unstable distortions of the shape of the plasma/magnetic field system.

Micro-instabilities
Instabilities with characteristic wavelengths comparable to the ion Larmor radius, rather than tokamak dimensions. These are thought to be responsible for the fine-scale turbulence in tokamaks, and hence anomalous transport.

Minor radius
If the tokamak plasma were a ring doughnut, half the thickness of the dough (see Figure 11.1).

Mode
Another word for wave or oscillation in a plasma. Also used, independently, in place of the word ‘regime’ (e.g. H-mode).

Mode number
Characterises the wavelength of a mode.

Monte Carlo
A statistical technique used in numerical calculations whereby one of a number of events may occur many times, each with a certain probability.

Motional Stark effect (MSE)
Particles moving transversely to a magnetic field experience an electric field. This gives rise to Stark splitting of spectral lines which can be interpreted to reveal the local magnetic field inside the tokamak. This is a major diagnostic on some tokamaks (including JET) used to deduce the current and therefore the q-profile (*q.v.*). A system is being implemented on MAST.

Muon-catalysed fusion
By substituting muons for electrons, fusion can occur between atoms at much lower temperature (i.e. not in the plasma state) than ‘normal’ fusion. The technique is not generally believed to be applicable for commercial energy production.

NBI
Neutral beam injection. See neutral beam heating and current drive.

Neo-classical
Classical collisional plasma transport theory, corrected for toroidal effects. The neo-classical theory predicts the existence of the bootstrap current.

Neo-classical tearing mode, Neo-classical instability
The magnetic island produced by a tearing mode perturbs the bootstrap current (*q.v.*), which further amplifies the island and degrades confinement or leads to a disruption. This instability is the neo-classical tearing mode.

Neutral beam heating and current drive
The injection of a beam of fast neutral particles which become ionised in the plasma and heat the plasma as they slow down. This process can result in current drive. Used on START, MAST, JET and many other devices. See also PINI.

Neutral particle analyser - See charge exchange.

Neutrons
Electrically neutral particles. Products of deuterium-tritium and other fusion reactions.

NINI
Negative Ion Neutral Injector (cf. PINI).

NNBI
Negative ion Neutral Beam Injection. At the high energies (~ 1 MeV) needed to heat ITER plasmas, the fast neutrals injected in NBI have to be created by neutralising negative ions, as the efficiency of neutralisation of positive ions (used in almost all today’s tokamaks including MAST and JET) is too low at these energies.

Non-inductive heating and current drive
See additional heating and current drive (non-inductive)

Notifications - See S/T Tasks

NSTX
Spherical tokamak at Princeton, USA. A contemporary of MAST and of similar size, but different design.

Ohmic heating (OH)
Inductive heating by using a transformer to drive a current in the plasma. This is necessarily pulsed.

Operating limits - See tokamak operating boundaries

Optimised shear
A regime in which the current distribution is adjusted to optimise tokamak performance (see reverse shear).

Orders - See S/T Tasks

Peeling mode
An edge MHD instability that can exist when the current density at the plasma edge is non-zero. It is thought to be associated with ELMs.

Pegasus
An ultra-low aspect ratio spherical tokamak in Wisconsin, USA.

Pellet injection
The plasma core density can be increased by firing pellets of frozen fuel into it; this is often observed to improve confinement in tokamaks.

PINI
Positive Ion Neutral Injector (sometimes “Plug In Neutral Injector”), a type of system used to inject neutral particle beams for heating and current drive, e.g. on JET and MAST.

Plasma confinement
A measure of the retention of plasma within a particular region.

Plasma parameters
Physical quantities that characterise the plasma and can be deduced experimentally, e.g. density, temperature, confinement time, beta.

Plasma pressure
Proportional to the product of plasma density and temperature. In magnetic confinement devices, this outward pressure is counterbalanced by magnetic forces. In the relevant temperature range (~100-200 million^{o}C), the fusion power output is approximately proportional to the square of the plasma pressure.

Polarimetry
Measurement of the rotation of the plane of polarisation of light or other electromagnetic waves; used to measure the local magnetic field and thus the safety factor (cf. Faraday rotation).

Poloidal field (PF)
Component of the magnetic field parallel to the minor circumference of the torus. The poloidal field is essential for confinement and, in a tokamak, is generated by the plasma current; this is in contrast to the larger toroidal field, which is generated primarily externally.

Power density
The power density of reacting fusion devices is characterised by the energy carried across the first wall by primary neutrons: this varies in the poloidal direction. The average value planned for ITER is 0.5 MWm^{-2}, and for demonstration tokamak power plants values in the range 2.0 - 2.5 MWm^{-2} have been proposed.

Power threshold
The L-H transition (and also improved performance regimes related to reverse shear) occurs when the power exceeds a certain threshold value - the power threshold.

Power Plant Conceptual Study (PPCS)
A major European study of a range of conceptual fusion power stations completed in early 2005.

Preliminary Tritium Experiment (PTE)
Three plasma discharges on JET, into which a significant amount of tritium was injected for the first time in a tokamak (November 1991). The power produced from fusion reactions (~2 MW for ~2 seconds) was in accordance with theoretical expectations.

Profile
Spatial variation of parameters from the centre to the edge of the plasma.

Profile control
Control of the profiles of pressure, density or current, to improve performance and/or stability.

Pumped divertor
Divertor with magnetic field lines directed into a pumped chamber surrounding the target plate. The inclusion of a pump (e.g. cryo-pump) into the divertor structure acts to control impurities and plasma flow. ITER will have a pumped divertor, and several existing tokamaks have one.

q - See safety factor

Q - See breakeven

Radial electric field
Arises when there is a charge imbalance in the plasma. A spatially varying radial electric field is usually associated with improved confinement regimes.

Reflectometry
Use of reflected microwaves to measure density.

Relaxation
The evolution of a plasma to a lower energy state, usually by means of turbulence or magnetic reconnection.

Resistive instability
Instability due to diffusion and rearrangement of magnetic field lines. When the plasma resistivity is small, these instabilities have a slow growth rate.

Resistivity
The tendency to resist the flow of electric current, thereby dissipating energy. Plasmas are very good conductors of electric current, so that as a first approximation their resistivity can often be neglected. In this case ‘ideal’ MHD may be applied.

Resistive wall mode (RWM)
Certain dangerous, rapidly-growing plasma instabilities that occur at high β can be stabilised by placing a conducting material wall close to the plasma. Instead, a resistive wall instability grows at a slow rate, proportional to the wall resistivity. Experimental and theoretical evidence suggests that the RWM can be influenced by plasma flow and this may play a role in developing a capability to stabilise it.

Resonant ions/electrons
Resonance occurs when one of the characteristic frequencies of particle motion in the plasma (for example, the cyclotron frequency) matches the frequency of some applied perturbation (for example, an RF wave).

Resonant magnetic perturbation (RMP)
An externally applied magnetic perturbation matched to the spatial structure (and optionally the frequency and phase) of an instability.

Reverse field pinch (RFP)
A toroidal magnetic confinement device in which the poloidal and toroidal fields are of comparable magnitude. To maintain stability the toroidal field reverses close to the edge of the plasma when a critical plasma current is exceeded. Devices employing this concept are studied in Italy, Sweden, Japan and the USA.

Reverse (magnetic) shear
In a tokamak the current density is usually greatest at the magnetic axis, in which case the 'safety factor' (q.v.) rises from the centre to the edge of the plasma. Using non-inductive current drive and/or the bootstrap current, the current density can be made to be greatest away from the centre. In this 'reverse shear' case, the safety factor has a minimum away from the plasma centre. Using reverse or low shear ('optimised shear') some tokamaks, notably DIII-D and TFTR in the USA, JT-60U in Japan and JET, have shown greatly improved plasma performance. Reverse shear is a potentially attractive option for steady state tokamak scenarios.

RF
Radio-frequency: important frequencies generally lie between 20 MHz and 200 GHz.

Ripple
The main, toroidal magnetic field of a tokamak is produced by a number of coils (there will be 18 on ITER). This results in a small ripple in the field, with it being biggest in the plane of the coils and smallest between the coils. The ripple can affect the plasma giving, for example, increased losses of very fast ions.

Runaway electrons, 'Runaways'
Fast, concentrated beams of electrons (runaway electrons) may be produced during disruptions in ITER, and could cause damage to plasma-facing components.

Saddle coils
Special coils, e.g. on JET, for generating artificial error fields for instability studies.

Safety factor (q)
Number of turns that the helical magnetic field lines in a tokamak make around the major circumference for each turn around the minor circumference, denoted by q. There is no connection with the ordinary sense of 'safety'.

Sawtooth
A cyclically recurring instability affecting the central region of tokamak discharges. The temperature periodically falls abruptly ("crashes"), then slowly recovers. The jagged trace produced by plotting temperature or other parameters against time gives the instability its name.

Scaling laws
Empirical or theoretical expressions for how various quantities (e.g. confinement time, power threshold, etc.) vary with the tokamak conditions (size, shape, current, etc.). These scaling laws involve a range of free parameters that are determined by 'best fits' to tokamak data. They are particularly useful for predicting the performance of future tokamaks.

Scrape-off layer (SOL)
The small amount of residual plasma between the 'edge' of the plasma (defined by the limiter or the separatrix) and the tokamak vessel - the region of plasma exhaust.

Semi-empirical
A theoretical approach whereby the behaviour of some of the key quantities is deduced from experiment, rather than *a priori*.

Separatrix
Boundary separating magnetic field lines that intersect the wall (open lines) and the closed magnetic field lines that never intersect the wall (closed lines).

SERF
Socio-Economic Research in Fusion: part of the European fusion programme.

Shear
Refers to the spatial variation, i.e. gradient, of either plasma flow (velocity shear) or safety factor (magnetic shear). If the type of shear is not specified, it usually means magnetic shear.

Single/double null (SN/DN)
Points of zero poloidal magnetic field where the separatrix crosses itself (i.e. X-points): usually above and/or below the plasma. Most tokamak divertor configurations have either one or two nulls. In connected double null (C-DN) discharges, the two zeros in the poloidal field both lie on the separatrix.

Single fluid model
The set of equations which represent a plasma as a magnetised, electrically conducting fluid with the usual fluid properties of viscosity, thermal conductivity, etc. The possibility of distinct behaviour of electrons and ions (i.e. two 'fluids') is not included.

Spectroscopy
The detection and analysis of the spectrum of radiation emitted by a plasma. This can yield information about temperatures, impurities, rotation, etc. Different parts of the electromagnetic spectrum (IR, visible, VUV, XUV, etc.) can be used.

Spherical Tokamak (Torus) (ST)
A very low aspect ratio tokamak (see Figure 11.1) – the plasma resembles a cored apple, and so appears almost spherical (although topologically it remains a torus). MAST is a spherical tokamak.

Spheromak
A spherical plasma (with no centre rod) in which comparable toroidal and poloidal currents flow. The toroidal current is not driven by transformer action.

ST – See Spherical Tokamak

S/T (Science and Technical) Tasks
The experimental programme on the JET facilities since January 1 2000 has been organised and conducted in Experimental Campaigns (of typically a few months) by (currently nine) topical Task Forces comprising staff from the European fusion Associations. The programme is defined and financed by a system of Orders and Notifications issued by the EFDA JET Associate Leader and his CSU.

Stability theory
The theory of how small perturbations to a system evolve in time. Spontaneous growth occurs in an unstable system. Instabilities can saturate at some small amplitude, in which case they degrade confinement, or grow uncontrollably, in which case confinement is lost (e.g. in a disruption).

START
Small Tight Aspect Ratio Tokamak at Culham. The first Spherical Tokamak with hot plasmas. Holder of the world record plasma β for a tokamak. Experiments ceased in 1998, for completion of its successor, MAST.

Start-up assist
Assisting plasma formation to minimise the start-up time and transformer requirements.

Steady-state power plant
A continuously (as opposed to cyclically) operated power plant.

Stellarator
A magnetic confinement device in which the poloidal magnetic field is generated by external helical coils (unlike the tokamak in which it is generated by a current in the plasma). In general, stellarators have not been quite as successful as tokamaks although a considerable level of research continues, notably in Germany, Spain, USA, Japan, Australia, Russia and Ukraine.

Super-Alfvénic velocity
A velocity greater than the Alfvén speed, which is a typical velocity associated with MHD behaviour. In a tokamak, energetic particles can have super-Alfvénic velocities; because they satisfy this condition, they may resonantly transfer their energy to MHD modes, which can grow as a result (e.g. TAE modes).

T-10
A conventional tokamak with circular cross-section and electron cyclotron heating at the Kurchatov Institute in Moscow.

TAE modes
Toroidal Alfvén eigenmodes (*q.v.*)

Task Forces (TFs) - See S/T Tasks

TCV
(Tokamak à Configuration Variable) Swiss conventional aspect ratio tokamak, designed to study the effects of plasma shaping on performance limits and confinement.

Tearing magnetic islands
The disturbance (caused by a tearing mode) which alters the topology of the confining magnetic field and permits transfer of heat across the affected region. See also 'Magnetic Islands'.

Tearing mode
A class of resistive MHD instability which produces magnetic islands (*q.v.*). It has been predicted theoretically in tokamaks and positively identified in experiments.

Temperature pedestal
In H-mode there is a region of steep temperature gradient at the plasma edge. The temperature at the top of this steep gradient region is the temperature pedestal.

TEXTOR
Mid-sized, circular cross-section tokamak, sited at Jülich, Germany.

TFTR
'Tokamak Fusion Test Reactor' at Princeton, noted for a major campaign of using deuterium-tritium fuel in 1993 - 1997. Ceased operation in 1997.

Thermal cycling
Successive heating and cooling of materials that can lead to cracks, rupture, etc., particularly at boundaries between materials that expand at different rates.

Thermal particles
As a result of collisional energy exchange, the energies of most plasma particles fall within a distribution that can be described by a single temperature (typically 1-30 keV for tokamaks). These are the thermal particles, as distinct from energetic particles, which lie outside the thermal equilibrium.

Thomson scattering diagnostic
Diagnostic to measure electron temperature and density by detecting laser light scattered and Doppler shifted by the plasma electrons. LIDAR is a version of this (analogous to radar but using visible light not radio waves), in which the scattered light is viewed along the same path as the incident beam.

Tight aspect ratio
Low aspect ratio, generally well below 2.

TJ-II
A stellarator operating in Madrid, Spain.

Tokamak
The most successful device yet found for magnetic confinement of plasma. Its magnetic field is made up from helical lines of force on toroidal surfaces, and is generated both by external field coils and by the current in the plasma.

Tokamak operating boundaries
The set of plasma parameters (e.g. density, current, pressure) beyond which it is impossible to operate a tokamak. Careful control of plasma cross-sectional shapes and current and density profiles can extend the operating boundaries.

TORE SUPRA
A long pulse tokamak at Cadarache, France, with superconducting coils.

Toroidal Alfvén eigenmodes
Alfvén gap modes arising specifically from the toroidal nature of tokamak plasmas.

Toroidal field (TF)
The toroidal (largest) component of a tokamak magnetic field, produced by coils external to the plasma.

Toroidal stability
Stability analysis taking account of effects due to toroidal geometry. These are sometimes neglected to identify possible instabilities, but must usually be included for accurate predictions of stability criteria.

Torsatron
A stellarator (*q.v.*) configuration with continuous helical coils. Modular designs in which the continuous coils are replaced by a number of discrete coils producing a similar field are also possible.

Trace Tritium Experiment (TTE)
An experimental campaign on JET in which trace amounts of tritium were used to act as markers in order to follow particle transport and other phenomena (September - October 2003).

Transformer drive
The use of transformer action to produce plasma current.

Transport
The processes by which particles and energy in the centre of the plasma are lost to the edge. Also the flow of particles and energy along the scrape-off layer to the divertor.

Transport barrier
In certain operational scenarios (e.g. the H-mode) an insulating layer of low transport, giving rise to a steep pressure gradient. Transport barriers reduce energy losses and so the central plasma pressure and hence the overall fusion performance increase.

Transport scaling
The magnitude of heat transport may be expressed, empirically or theoretically, in terms of a simple functional dependence on a few plasma parameters. This makes it possible to model the variation ('scaling') of heat transport in response to changes in the values of these parameters.

Trapped particles
The outside (large major radius) of a tokamak plasma has a lower magnetic field than the inside. Particles with a relatively small velocity component parallel to the magnetic field may be trapped on the outside. They are not free to circulate toroidally but instead bounce back and forth, performing so-called banana orbits.

Tritium
An isotope of hydrogen, whose nucleus consists of one proton and two neutrons. Tritium does not occur naturally, because it is unstable to radioactive decay. For this reason, special tritium-handling technology is required whenever the use of deuterium-tritium plasmas is contemplated, as in JET and future fusion power plants.

Turbulence, Turbulent transport
Randomly fluctuating, as opposed to coherent, wave action. For example, the turbulent water beneath a waterfall can only be described in terms of its averaged properties, such as the scale and duration of fluctuations, whereas a more systematic description can be given to waves on the surface of a still pond. In a plasma, it results in anomalous transport of heat and particles.

Two-fluid model and multi-fluid model
The extended set of equations which represent a plasma as interpenetrating and interacting fluids of electrons, ions, impurity ions etc.

Vertical displacement event (VDE)
An event which arises when control of the plasma is lost and the plasma moves vertically. It can lead to 'halo currents' in components which surround the plasma, resulting in large, potentially damaging, forces on these components. The forces are much larger in larger tokamaks and are therefore a particular concern for JET and ITER.

Volume Neutron Source (VNS)
Another term for a Component Test Facility (*q.v.*).

VUV
The 'vacuum ultra violet' range of the electromagnetic spectrum.

WENDELSTEIN 7-X, W7-X
A large advanced stellarator with superconducting coils under construction in Germany. A successor to the W7-AS device which ceased operation in 2002.

X-point - See single/double null

XUV
The 'extreme ultra violet' range of the electromagnetic spectrum. Shorter wavelengths than VUV.

Z_{eff}
The effective charge of a plasma, a measure of its impurity content: Equals 1 for a plasma with no impurities.

Z-pinch
Linear device in which a large current is rapidly produced in a wire or array of wires. Studied in the USA, Imperial College London, and elsewhere.