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ISDEP, a Fusion Application Deployed on a Volunteer Computing Platform

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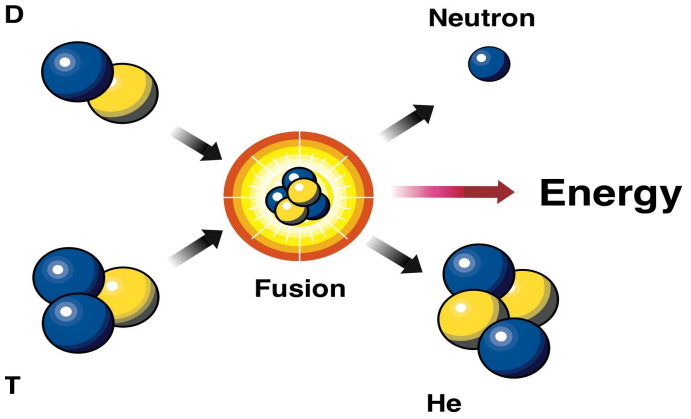
Nuclear fusion

Fusion: process by which multiple atomic particles join together to form a heavier nucleus. Nuclear fusion occurs naturally in stars.



To avoid electrostatic repulsion, high temperature (10 KeV ~ 100.000.000ºC)

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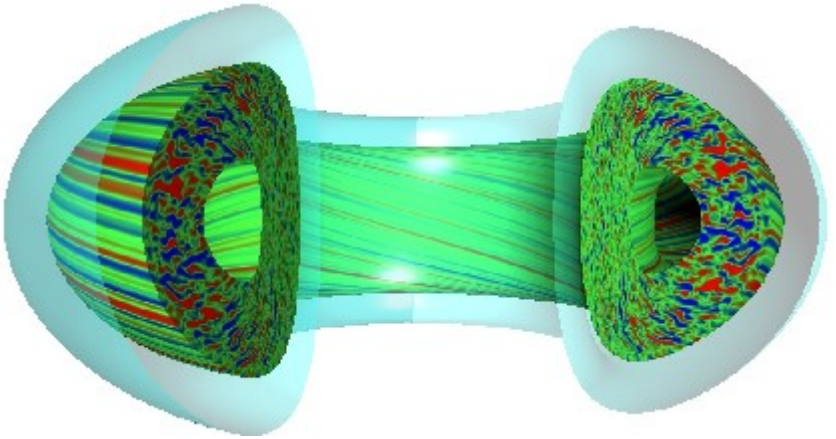
Nuclear fusion

Plasma: ionized gas, in which a certain proportion of electrons are free. It is considered to be a distinct state of matter.

- Electrically conductive
- Low number of collisions
- Collective Phenomena



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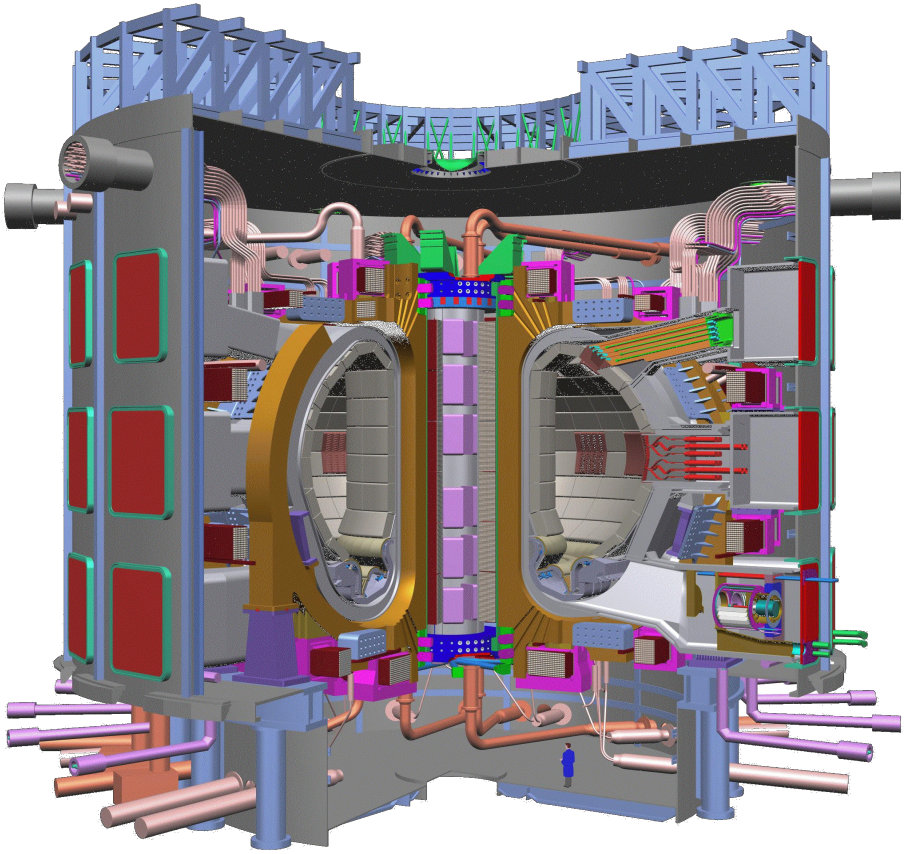
Nuclear fusion

- **Next generation of energy production: social and environmentally acceptable**
- **It still has many open issues: plasma confinement & material science.**
- **It becomes not only a scientific problem but also a large scale computational problem where distributed infrastructures and HPC are required:**
  - Experimental data processing.
  - Experimental scenario development.
  - Theory.



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Simulation

ISDEP: C Code that aims to solve the dynamics of a fusion plasma starting off of first principles.
- The equations that govern the plasma are extremely difficult to solve, they are nonlinear equations in partial derivative in many dimensions. geometry.

ISDEP launches ions and make them evolve with the background and extern electromagnetic fields

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ISDEP Bases

Plasma → Physics are modelized by Langevin approach

Diff. Eq. → Solution

Equations are solved with Runge-Kutta methods

Trajectories are independent

Each trajectory (job) is calculated in one different node

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ISDEP

- **ISDEP: Integrator of Stochastic Differential Equations in Plasmas.**
- **Following a huge number of independent ions moving in a background plasma (typically ~ 10^6 – 10^7 particles)**
- **Every ion on a single CPU. For ITER, a single trajectory can take 30 min and 40 MB. A typical problem ~ 10^6 h CPU time)**
- **The complex magnetic structure, the collisions with the background (elecrons and ions) and the electric field are taken into account.**
- **The global properties are averages measured on the population of ions.**

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Antecedent Grid projects

ISDEP is using EGEE (Enabling Grids for E-sciencE)
Batch jobs

ISDEP and its visualizator have been ported to int.eu.grid (Interactive European Grid)
Interactive jobs

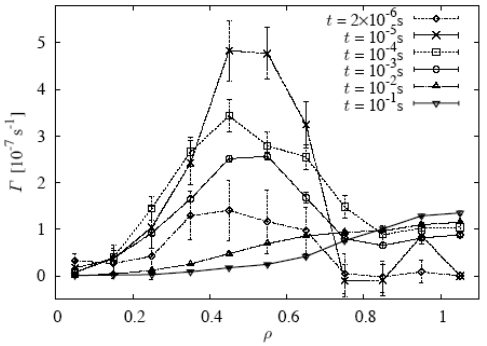
ISDEP in the TJ-II version was used in the local BOINC project called ZIVIS
Batch jobs

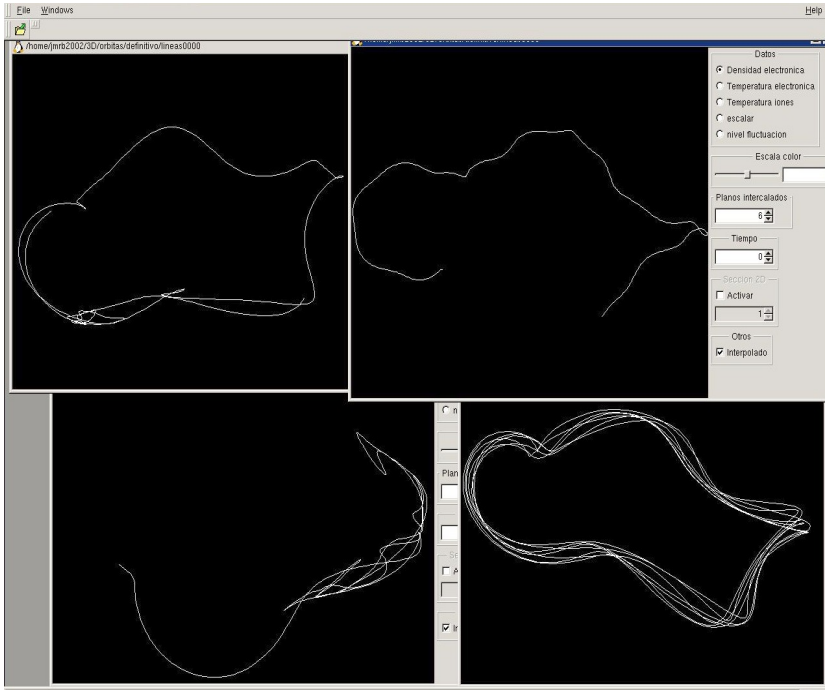
ISDEP: The 1st Grid application.

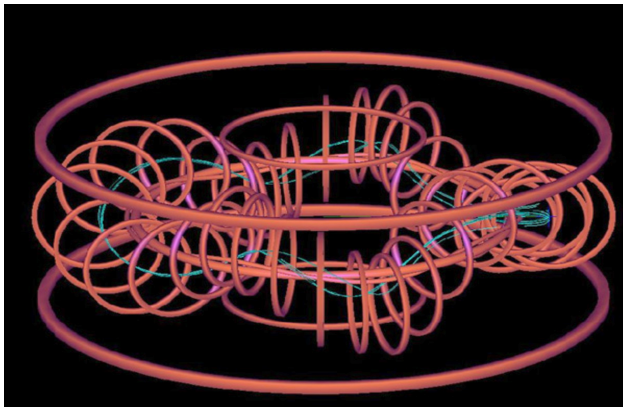
- PREVIOUS RESULTS ON THE GRID:

SIMULATIONS OF TJ-II STELLARATOR

[F. Castejón et al. Plasma Physcs and Controlled Fusion, 2007]







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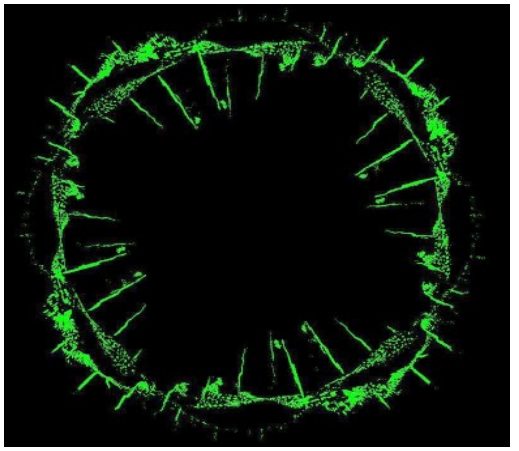
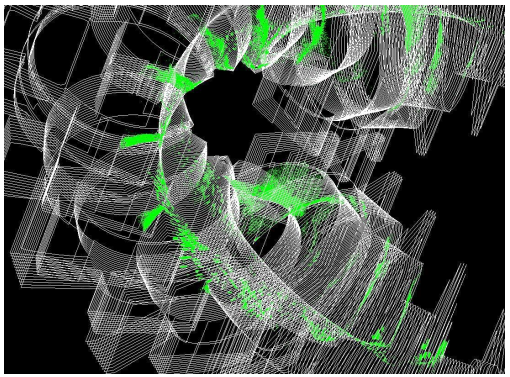
ISDEP at TJ-II



- Studies of the 3D particle fluxes on the vacuum chamber.
- Follow the particles until the chamber wall.
- Toroidal and poloidal Asymmetries that depend on plasma conditions.
- [F. Castejón et al. Nuclear Fusion, 2010]



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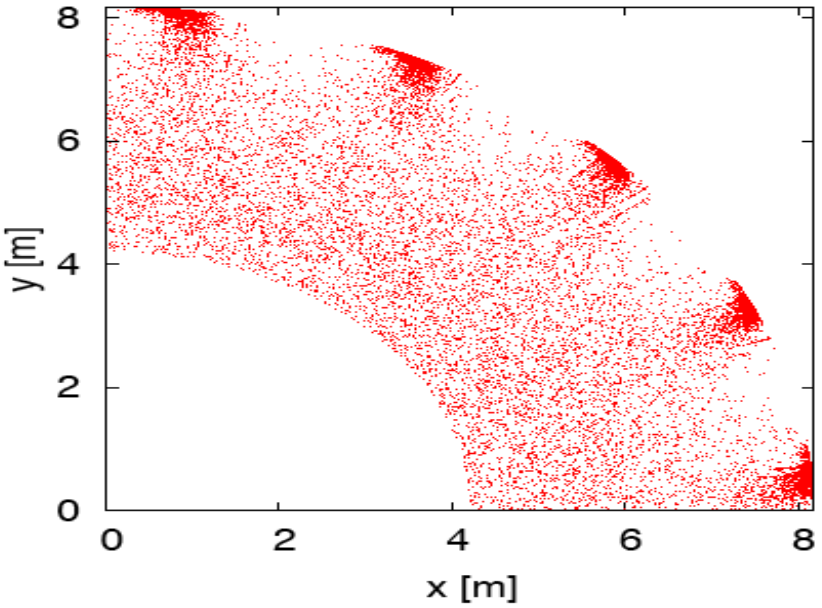
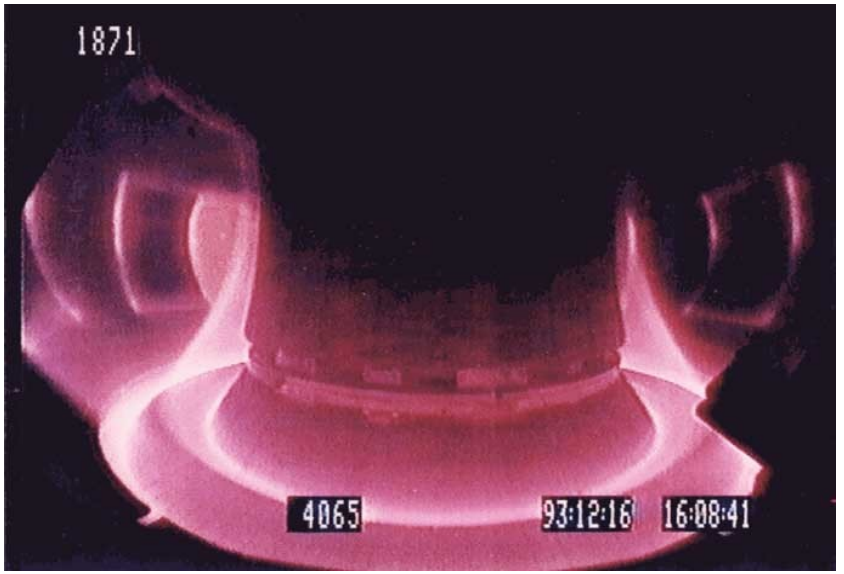
MC Calculations of ISDEP for ITER

- ITER is in fact a 3D tokamak.
- It presents a FULL 3D STRUCTURE (the magnetic field is not toroidally constant, it presents a toroidal ripple).
- The usual Neoclassical Calculations do not work.
- We need to use the same techniques as in TJ-II: Grid, desktop Grid and large MC codes.





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Papers

3D features of 2D transport in ITER: results from Ibercivis (a Citizen Supercomputer).

Journal: Physics of Plasmas

Authors: Francisco Castejón, Luis Antonio Fernandez, Jerónimo García, Victor Martin Mayor, Alfonso Tarancón, José Luis Velasco.

A stable infrastructure of volunteer computing

Journal: Vértices (Spain)

Authors: Alfonso Tarancón, Francisco Castejón.

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ISDEP in BOINC

ISDEP ported to BOINC

- C application crosscompiled for Windows, Linux, Mac
- BOINC API calls, templates fixed, validation mechanism

ISDEP runs in Ibercivis

- Ibercivis: Based on BOINC
- Ibercivis connected to EDGeS VO trough bridge

ISDEP runs in EDGeS@home

- Fusion WUs sets are available periodically
- Results are being analyzed

ISDEP in Desktop Grids (EDGeS@home)

GOALS:

Huge number of workunits (millions)

Replication & validation process, so the app is running with no fails

Easy for researchers to run the apps, see the status and receive the output

Lacks:

Can't run the app configured for use a lot of ram and disk

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Thanks For Your Attention

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