stellarator news

**Published by Fusion Energy Division, Oak Ridge National Laboratory**
**Building 5700 P.O. Box 2008 Oak Ridge, TN 37831-6169, USA**

Editor: James A. Rome Issue 110 August 2007
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On the Web at *http://www.ornl.gov/sci/fed/stelnews*

# Zivis: Deployment of a citizen supercomputer for stellarator calculations

Zivis, the first citizen supercomputer that has operated in Spain, has been deployed in the middle-sized city, Zaragoza. Teams from the Instituto de Biocomputación y Física de Sistemas Complejos (BIFI, http://bifi.unizar.es), which is part of Zaragoza University, and of the Laboratorio Nacional de Fusión (http://www-fusion.ciemat.es), part of CIEMAT, have connected thousands of personal computers (PCs) in that city to perform calculations for the TJ-II stellarator.

Zivis is based upon the Berkeley Open Infrastructure for Network Computing (BOINC) software developed at the University of California, Berkeley, and uses the PCs of the volunteers to perform distributed calculations that produce relevant scientific results. The target of computations developed in Zivis is the study of the ion collisional transport in the TJ-II stellarator. A huge number of ion trajectories have been followed in several magnetic configurations in the presence of electric field and with different collisionalities. The characteristics of the transport are extracted from the statistical properties of the trajectories.

The key point of this experience is to use the capacity of PCs that are idle for long periods of time to obtain relevant results for plasma physics research. The computer owners have only to download a screensaver from a Web page and, after three clicks on the mouse, their PCs become part of the virtual supercomputer deployed in the city. The software had to be downloaded from a web page that was hosted by the city council of Zaragoza (http://zivis.zaragoza.es). The support of this institution was essential to the success of the experience, since it is necessary to use a trusted Web site and good publicity to get a large number of citizen computers.

The size of the city was also an important factor. Zaragoza was selected because it is small enough that this kind of event would attract the attention of the people, and on the other hand, it is large enough to have an adequate number of people with a broadband internet connection at home. With these characteristics and the support of the city council, it was possible to engage the interest of the media, which helped to publicize the activity and allowed us to reach a high degree of citizen participation.

Of course, the kinds of computations that can be performed in an architecture like that of Zivis are a large number of independent processes whose results can be integrated by the organizers. Therefore, distributed computers like Zivis are ideal for Monte Carlo codes or for problems that can be solved by running the same process many times using different parameters.

Although Zivis was envisioned as being hosted on personal computers in the city of Zaragoza, in fact an appreciable number of computers from different places in Spain, Europe, the United States, and South America (Fig. 1) were connected to Zivis, showing that the initiative was propagated effectively by the Web. Zivis is a sociological experiment itself: The study of the way in which the PCs have been connected will show different patterns of information dissemination.

Eventually, more than 60% of the connected computers were in the city of Zaragoza. In this localized atmosphere it was possible to take different actions to promote participation in Zivis. Several publicity talks on fusion and on the use of the results obtained using Zivis were given.

## *In this issue . . .*

Also, several awards were granted to those who shared the largest amount of CPU time.

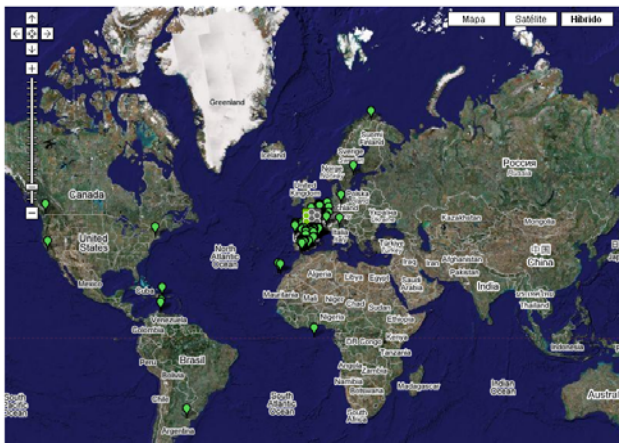



**Fig. 1.** World-wide distribution of computers connected to Zivis.

The results of the Zivis project show that the initiative was a big success. More than 3000 people have registered with Zivis and they have provided more than 5200 computers and about 7200 CPUs in total. Finally, more than 800,000 hours of CPU time were obtained during the month and a half (from April 3 to May 19, 2007) that Zivis lasted. These results are equivalent to having a cluster with 800 CPUs, which would be on the list of the top 500 supercomputers in the world and in the top 5 among Spanish supercomputers.

The Zivis experience can be extended to different places (other cities or other countries) in the future, provided that tools are available to publicize the initiative and to share the results of the computation with the participants. In fact, our next step will be to extend this experience to the whole country and to convert the equivalent of Zivis into a stable computer infrastructure in Spain. This Spanish citizen supercomputer will be called Ibercivis. The added value of this kind of computations is that the citizens decide to contribute to some research activities, increasing their own commitment to the research topic. The Zivis initiative has been very useful for publicizing fusion research, and for increasing the social support for this kind of research and for fusion as an energy source.

As mentioned above, the first application that has run in Zivis is devoted to fusion research. A Monte Carlo code that follows ion trajectories in TJ-II was developed by BIFI and CIEMAT fusion teams, who are analyzing the results obtained in Zivis. The application was chosen for two main reasons. First, it is possible to obtain relevant results from these totally distributed calculations. Second, fusion research is an activity attractive enough to encourage people to contribute to it. Citizens are worried about energy problems, and fusion is perceived as an environmentally friendly energy source that will not contribute to global warming.

The concrete activity has been to explore the ion confinement and transport in the TJ-II stellarator. The trajectories of a large number of independent ions, which are confined in the complex TJ-II geometry and suffer the effects of electric field and ion and electron collisions, are calculated. The background plasma is constant during the calculation, which is equivalent to considering the linearized problem. The electrostatic potential profile is similar to the experimental one, taken from heavy ion beam probe (HIBP) measurements; the ion temperature and density profiles are taken from the charge-exchange neutral particle analyzer and from Thomson scattering. In this way, interesting conclusions about the transport properties due to collisions and electric field can be extracted. Different plasma parameters have been considered to explore how the confinement properties vary from plasmas with electron cyclotron heating (ECH) to plasmas heated using neutral beam injection (NBI). The obtained results are scientifically relevant, and the citizens have contributed in this way to fusion research. As many as $5 \times 10^6$ trajectories have been estimated in TJ-II, which provides enough statistics to diminish the error bars. An example of this output is shown in Fig. 2.

The future role of this kind of computer architecture can be important in scientific research as networks and PCs become more and more powerful. With this type of architecture, several research teams could have access to a large amount of cheap computer power, with the extra value of connecting citizens to scientific research.

Francisco Castejón
Laboratorio Nacional de Fusión (CIEMAT)

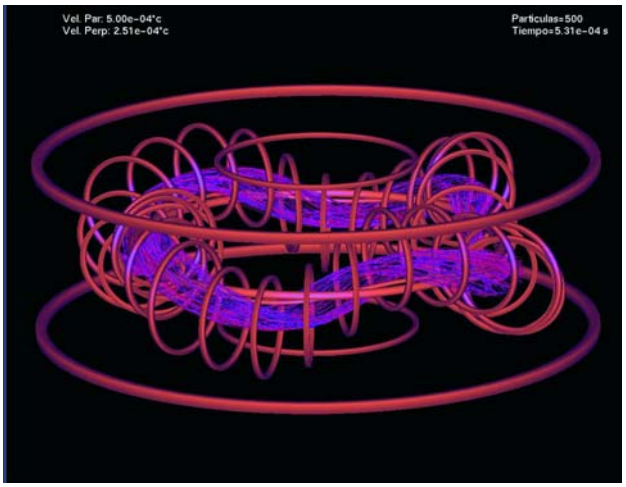
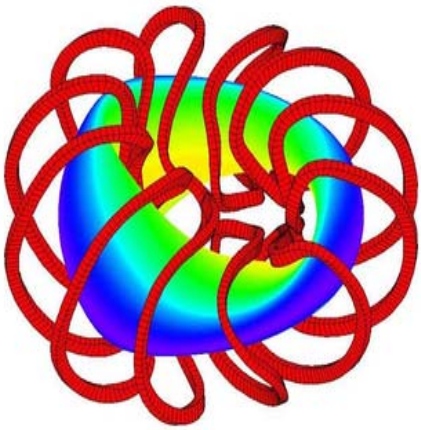



**Fig. 2.** Example of 500 ion trajectories in TJ-II estimated with Zivis.

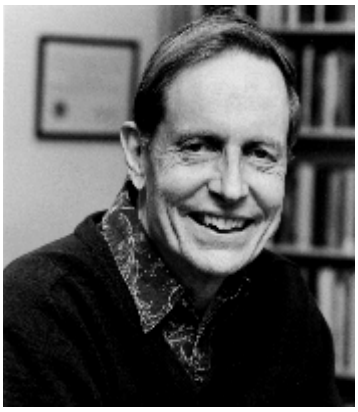
## A birthday tribute to Paul Garabedian from ORNL

*Stellarator News* joins with staff members at ORNL in wishing a happy 80th birthday to Paul Garabedian. The card that was sent to Paul is reproduced below.

Paul is still an active participant in stellarator design, as witnessed by his latest device shown at right.



A quasitoroidal optimized stellarator. From Romeo Alexander and Paul R. Garabedian, "Choice of coils for a fusion reactor." Proceedings of the National Academy of Sciences, July 24, 2007, **104**, 12250–12252.



# HAPPY BIRTHDAY!

# Professor Paul R. Garabedian

**Director, Division of Computational Fluid Dynamics**

Courant Institute of Mathematical Sciences
New York University

**You taught us PDEs, method of characteristics, Monge cones, conformal mappings and all that *fun* stuff we studied in graduate school.**

**Thanks to you and your endeavors, the U.S. now has a new stellarator called NCSX! Just as you inspired us, you continue to teach a new generation of physicists and mathematicians interested in designing the next generation stellarators.**

**Best wishes on your 80$^{th}$ birthday!**

***Steven Hirshman, Jeffrey Harris, Jim Lyon, Don Spong***

*Oak Ridge National Laboratory*