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Minutes of the VC on the Coupling of Free Boundary Equilibrium and Transport Codes 08/11/2010

Participants: G. Falchetto, F. Imbeaux, V. Basiuk, S. Brémond, R. Coelho, R. Paccagnella, J. Lister, K. Besseghir, F. Koechl, C. Boulbe, W. Zwingmann, T. Bolzonella, E. Fable, D. Kalupin, C. Angioni, D. Coster, C. Konz, E. Giovannozzi, G. Pautasso, B. Faugeras, J. Blum, G. Selig (afternoon: R. Zagorski, D. Borba, B. Scott)

1. Presentations:

The agenda and the presentations can be found on the ITM website (http://portal.efda-itm.eu/) under Documentation/IMP12/Meetings/. Here, only additional comments and clarifications are listed.

Coupling between CREATE-NL and JINTRAC (F. Koechl)

The coupling of CREATE-NL and JINTRAC is done in such a way that the current diffusion equation is solved by the transport code JETTO. It then hands p' and FF' to CREATE-NL which calculates the new free boundary equilibrium. Since the new equilibrium may have a q-profile different from the one calculated by JETTO, an iteration between CREATE-NL and the fixed boundary equilibrium solver ESCO aims to restore the q-profile imposed by JETTO.

J. Lister expressed interest in a collaboration with JET on vertical kick simulations.

The CREATE-NL/JINTRAC system experiences resolution issues with high edge currents related to ETBs.

Run times are of the order of a few minutes per time step. With a time step of 50ms, the total runtime for a ramp-up case amounts to roughly 2 days. The bulk of the runtime is spent in the equilibrium solver and the routine to find the separatrix.

The FLUSH toolbox is used to map from the triangle representation of CREATE-NL to the quadrilaterals in ESCO.

Equilibrium and transport iteration are independent. The transport time step is completed before a new equilibrium is calculated.

The temporal gap evolution for the shape control is prescribed via the coil current evolution and the correction currents.

DINA-CH full tokamak simulator (J. Lister, K. Besseghir)

Since deformation of equilibrium has effect on voltages in coils, typically 10 iterations between equilibrium and transport code are required to converge on next time step.
Time steps are less or equal 2.5ms.

Setting up a self-consistent initial start-up condition is a major effort (up to 2 ppm compare to 10 minutes on experiment). Therefore, the addition of an intermediate restart option was of high importance.

Other than CREATE-NL + JINTRAC, no intermediate equilibrium code like ESCO is needed but DINA-CH imposes the equilibrium on CRONOS.

DINA-CH uses fixed (time invariant) rectangular grid.

Collaboration with S. Medvedev on MHD stability (challenging topic in terms of resolution and time scales).

The current diffusion equation is solved directly in DINA-CH while the current drive modules and the resistivity module are still provided by CRONOS. (Remark by D. Coster: Should current diffusion equation be moved into IMP12?).

Anything that is voltage induced should go into the equilibrium solver.

Bootstrap current calculated by CRONOS.

Free Boundary Equilibrium Code CEDRES++ (C. Boulbe, J. Blum)

No surface current on plasma-vacuum boundary.
No near-term plan to move current diffusion equation to CEDRES++ (J. Blum).

EQUAL in predictive mode (W. Zwingmann)

The inverse mode of EQUAL is under development.
PROTEUS is used at JET and Tore Supra.
EQUAL includes iron model.

E. Giovannozzi mentioned the plan to couple CREATE-NL and ETS. No details are yet available. Requires additional interaction with the CREATE team.

Other points discussed (open discussion):

Halo currents:
Neither CEDRES++ nor CREATE-NL include halo currents (current outside the separatrix).
For DINA-CH, a test case exists for MAST but not included in the reference version.

Boundary conditions:
Will be added by the code ROs.

Current diffusion equation:

- CRONOS: solves for psi in current diffusion
- JETTO: solves for q in current diffusion
- DINA-CH: solves for psi in current diffusion

In the plasma edge, current diffusion time scales (~1ms) and feedback time scales overlap, thus preventing a complete decoupling of transport and electromagnetic time scales. This might impact on the transport and e.m. covergence loops.
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Potential coupling models:

1) FreeBoundEq + (psi, ta, na, va) transport
   a) FreeBoundEq + FixBoundEq + (psi, ta, na, va) transport (CREATE-NL + JINTRAC)
   b) FreeBoundEq + (psi, ta, na, va) transport (CEDRES++ + CRONOS)
2) (FreeBoundEq + psi) + (ta, na, va) transport (DINA-CH + CRONOS)

Proposed approach:

From the presented codes, only CEDRES++ and EQUAL have been adapted to ITM standards. Since EQUAL's inverse mode is still under development, **CEDRES++** will be used as a first (but not exclusive) candidate for coupling to the **ETS**. Both **models 1a) and 1b)** shall be tested and the better option pursued in the near future. First tests will be possible during the ITM CC at Innsbruck in December 2010.
It remains to be discussed at the TFL+PL level whether the current diffusion equation shall be moved to IMP12. Additional meetings shall clarify the possibility of including the current **diffusion equation in CEDRES++ and CREATE-NL**.
A separate meeting with the CREATE team is required to work out a strategy for **adapting the CREATE-NL suite of codes to ITM standards** (C++ version?).
An additional meeting with the CREATE team shall also **explore the possibility of coupling the FIXFREE code to the ETS**.
It is advisable to start **first tests in open loop configuration**. The expected vertical instability of the plasma serves as a good test for the coupled FBE + Transport system. **Shape control shall be added in a second step**. The development activities on control by EDRG and IMP12 shall be directed towards a fast coupling of CEDRES++ and ETS.