Neutral Atom, Molecule and Edge-plasma Modeling for ITER

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Accomplishments in the last three years....

Over the past three years, eleven refereed journal publications[1-11] have resulted in part from this grant. These can be arranged into three categories: (1) Erosion/re-deposition calculations of current machines and proposed designs, (2) Analysis of proposed long-pulse or burning plasma operating regimes, and (3) Analysis of neutral behavior in current experiments. Each paper is listed below along with a very short synopsis of the importance or significance of the work in each category. Since refereed work in significant journals is the purest distillation of written results, the entire papers are included after these brief descriptions.

A. Erosion / Re-deposition

1. J.N. Brooks, D.N. Ruzic, D.B. Hayden, and R.B. Turkot Jr., "Surface Erosion Issues and Analysis for Dissipative Divertors," J. Nuclear Materials, 222, 269-273 (1995)
2. J.N. Brooks, R. Causey, G Federici, D.N. Ruzic, "Assessment of Erosion and Surface Tritium Inventory Issues for the ITER Divertor," J. Nuclear Materials, 241-243, 294-298 (1997).
3. J.N. Brooks, D.N. Ruzic, D.B. Hayden, "Sputtering Erosion of Beryllium Coated Plasma Facing Components-General Considerations and Analysis for ITER Detached Plasma Regime," Fusion Engineering and Design, 37, 332-337 (1997).
4. J.N. Brooks, G. Federici, D.N. Ruzic, D.G. Whyte, "Erosion/Redeposition in Fusion Tokamaks: Status of Modeling, Analysis and Code Validation", accepted in J. Nucl. Mater. (1998).

This work carried on in conjunction with Dr. Jeff Brooks and Argonne National Laboratory has highlighted the difficulty in attached plasma regimes using a Be surface covering. At those attachment points erosion is unacceptably high and dooms the concepts. Carbon walls were shown to have too high of tritium retention in the co-

deposited layers. Only W had acceptable erosion lifetimes and contamination for the throat of the divertors on a machine such as ITER. Validation work to DIII-D was also described.

B. Burning Plasma or Long-Pulse Operating Regimes

5. D.N. Ruzic, "Neutral Atom and Molecular Transport in a Gaseous Divertor," J. Nuclear Materials, 220-222, 1091-1096 (1995).
6. D.R. Juliano, D.N. Ruzic, D. Hill, K.A. Werley, "Sensitivity of Neutral Throughput to Geometry and Plasma Position in the TPX Divertor Region," Fusion Technology, 29, 269-276 (1996)
7. D.B. Hayden and D.N. Ruzic, "Simulation of Neutral Atoms and Molecules in an ITER High-Pressure (1Torr) Ultra-High Recycling Divertor," Fusion Technol., 31, 128-134 (1997).
8. D.N. Ruzic and D.B. Hayden, "Momentum and Energy Transfer via Neutral Atoms and molecules in an ITER Low-Pressure (10 mTorr) Gas Target Divertor," Fusion Technol., 31, 123-127 (1997).

These papers examined various operating regimes of ITER and TPX. In ITER it was shown that the completely detached solutions were unlikely to be obtained and indeed, they were abandoned as the most likely operating scenario in favor of the impurity enhanced semi-attached regime. In TPX the vertical target plate was shown to be superior for long-pulse neutral gas handling.

C. Neutral Behavior in Current Experiments

9. D.P. Stotler, C.H. Skinner, R.U. Budny, A.T. Ramsey, D.N. Ruzic, R.B. Turkot Jr., "Modeling of Neutral Hydrogen Velocities in TFTR," Phys. of Plasmas, 3(11), 4084-4094 (1996).
10. L.A. Haynes, J.P. Kelly, D.N. Ruzic, "Neutral Atom Modeling of the TFTR First Wall, Pump Ducts, and Neutral Beams," Fusion Technology, 33, 74-83 (1998).

11. D.N.Ruzic, Monica M.C. Allain, R.V. Budny, "The Effect of Lithium Wall Conditioning in TFTR on Plasma Surface Interactions.", accepted in J. Nucl. Mater. (1998).

In TFTR, the importance of including the sputtered D atoms from the D-saturated carbon walls was shown. Doppler broadening spectra could not be matched without including this component, first envisioned as a modeling result. The positive effects of Li-conditioning was also explained and the D-alpha emission matched by conducting thorough neutral modeling.