

URI SHUMLAK

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Education and Training

Postdoctoral: National Research Council Fellow, AFRL, Kirtland AFB, NM		1992-1994
Graduate: University of California, Berkeley CA	Nuclear Engr	PhD 1992
Undergraduate: Texas A&M, College Station TX	Nuclear Engr	BS 1987

Research and Professional Experience

UNIVERSITY OF WASHINGTON Seattle, WA
2007 to present: Professor, Aeronautics and Astronautics
2022 to present: Adjunct Professor, Applied Mathematics
2019 to present: Associate Chair for Academics, Aeronautics and Astronautics
2015 to 2018: Associate Chair for Research, Aeronautics and Astronautics
2014 to 2015: Acting Chair, Aeronautics and Astronautics
2010 to 2013: Associate Chair for Research, Aeronautics and Astronautics
2002 to 2007: Associate Professor, Aeronautics and Astronautics
1999 to 2002: Assistant Professor, Aeronautics and Astronautics
1994 to 1999: Research Assistant Professor, Aeronautics and Astronautics

WEIZMANN INSTITUTE OF SCIENCE Rehovot, Israel
2018 to 2019: Erna and Jakob Michael Visiting Professor

ZAP ENERGY Seattle, WA
2018 to present: Chief Scientist & Co-Founder

LAWRENCE LIVERMORE NATIONAL LAB Livermore, CA
2019 to present: Visiting Scientist
2018 to 2019: Faculty Scholar
2016 to 2018: Visiting Scientist

AIR FORCE RESEARCH LAB Albuquerque, NM
1994 to 1996: Visiting Scientist, IPA
1992 to 1994: Postdoctoral Fellow

Professional Awards and Honors (selected)

1. Fellow of the Institute of Electrical and Electronics Engineers (IEEE), 2023
2. Graduate Educator of the Year (Aeronautics & Astronautics, University of Washington), 2022
3. Fellow of the American Physical Society (APS), 2019
4. Plenary Speaker for IEEE International Pulsed Power and Plasma Science Conference, Orlando, Florida, 2019

5. Erna and Jakob Michael Visiting Professorship, Weizmann Institute of Science, 2018
6. Associate Fellow of American Institute of Aeronautics and Astronautics (AIAA), 2016
7. Graduate Educator of the Year (Aeronautics & Astronautics, University of Washington), 2016
8. President of University Fusion Association (UFA), 2015-2016. Vice-President of UFA, 2013-2014
9. Faculty Innovator Award (College of Engineering, University of Washington), 2011
10. Abe Zarem National Graduate Educator Award (American Institute of Aeronautics and Astronautics), 2003
11. Professor of the Year (Aeronautics & Astronautics, University of Washington), 2002
12. Certificate of Recognition by the University of Washington's Minority Science & Engineering ALVA Program (Alliances for Learning and Vision for Underrepresented Americans), 2000
13. Professor of the Year (Aeronautics & Astronautics, University of Washington), 1999
14. National Research Council Fellow, National Academy of Sciences, 1992-1994

Archival Journal Publications (selected)

1. U. Shumlak, E.T. Meier, and B.J. Levitt. Fusion Gain and Triple Product for the Sheared-Flow-Stabilized Z Pinch. *Fusion Science and Technology* **80**, 1 (2024).
2. P.J. Turchi and U. Shumlak. Some considerations of a flow-stabilized Z pinch for megagauss fusion. *IEEE Transactions on Plasma Science* **51**, 2679 (2023).
3. J. Coughlin, J. Hu, and U. Shumlak. Robust and conservative dynamical low-rank methods for the Vlasov equation via a novel macro-micro decomposition. *ArXiv* 2311.09425 (2023).
4. W.R. Thomas and U. Shumlak. Parametric study of 1D plasma photonic crystals with smooth and discontinuous density profiles. *Physics of Plasmas* **30**, 063503 (2023).
5. I.A.M. Datta and U. Shumlak. Computationally efficient high-fidelity plasma simulations by coupling multi-species kinetic and multi-fluid models on decomposed domains. *Journal of Computational Physics* **482**, 112073 (2023).
6. C. Stollberg, E. Kroupp, D. Mikitchuk, P. Sharma, V. Bernshtam, M. Cvejic, R. Doron, E. Stambulchik, Y. Maron, A. Fruchtman, I. E. Ochs, N. J. Fisch, and U. Shumlak. Observation of fast current redistribution in an imploding plasma column. *Physical Review Letters* **130**, 205101 (2023).
7. M.C. Thompson, B. Levitt, B.A. Nelson, and U. Shumlak. Engineering Paradigms for Sheared-Flow-Stabilized Z-Pinch Fusion Energy *Fusion Science and Technology* **79**, 1051 (2023). [Invited Article]
8. A.W. Klemmer, S. Fuelling, B.S. Bauer, G.A. Wurden, A.S. Taylor, D.A. Sutherland, A.P. Shah, A.D. Stepanov, B.J. Levitt, B.A. Nelson, T.R. Weber, and U. Shumlak. Extreme ultraviolet spectroscopy on a sheared-flow-stabilized Z pinch. *Review of Scientific Instruments* **94**, 083507 (2023).
9. J.T. Banasek, C. Goyon S.C. Bott-Suzuki, G.F. Swadling, M. Quinley, B. Levitt, B.A. Nelson, U. Shumlak, and H.S. McLean. Probing Local Electron Temperature and Density inside a Sheared Flow Stabilized Z-Pinch using Portable Optical Thomson Scattering. *Review of Scientific Instruments* **94**, 023508 (2023). [Featured Article, Scilight Selection]

10. S.S. Harilal, U. Shumlak, and J. Little. Guest Editorial Special Issue on Plenary, Invited, and Tutorial Papers From ICOPS 2022. *IEEE Transactions on Plasma Science* **51**, 943 (2023).
11. D.W. Crews, and U. Shumlak. On the validity of quasilinear theory applied to the electron bump-on-tail instability. *Physics of Plasmas* **29**, 043902 (2022).
12. S. Taheri, J.R. King, and U. Shumlak. Time-discretization of a plasma-neutral MHD model with a semi-implicit leapfrog algorithm. *Computer Physics Communications* **274**, 108288 (2022).
13. E.T. Meier and U. Shumlak. Development of five-moment two-fluid modeling for Z-pinch. *Physics of Plasmas* **28**, 092512 (2021).
14. I.A.M. Datta, D.W. Crews, and U. Shumlak. Electromagnetic extension of the Dory-Guest-Harris instability as a benchmark for Vlasov-Maxwell continuum kinetic simulations of magnetized plasmas. *Physics of Plasmas* **28**, 072112 (2021).
15. J.M. Mitrani, J.A. Brown, B.L. Goldblum, T.A. Laplace, E.L. Claveau, Z.T. Draper, E.G. Forbes, R.P. Golingo, H.S. McLean, B.A. Nelson, U. Shumlak, A.D. Stepanov, T.R. Weber, Y. Zhang, and D.P. Higginson. Thermonuclear neutron emission on a sheared-flow stabilized (SFS) Z-pinch. *Physics of Plasmas* **28**, 112509 (2021). [Invited Article]
16. C. Stollberg, E. Kroupp, D. Mikitchuk, P. Sharma, V. Bernshtam, M. Cvejić, R. Doron, E. Stambulchik, Y. Maron, A. Fruchtman, I. E. Ochs, N.J. Fisch, and U. Shumlak. Observation of fast current redistribution in an imploding plasma column. *ArXiv* 2111.06450 (2021).
17. U. Shumlak. Z-Pinch Fusion. *Journal of Applied Physics* **127**, 200901 (2020). [Featured Article, Invited Perspectives Article]
18. A.D. Stepanov, U. Shumlak, H.S. McLean, B.A. Nelson, E.L. Claveau, E.G. Forbes, T.R. Weber, and Y. Zhang. Flow Z-pinch plasma production on the FuZE experiment. *Physics of Plasmas* **27**, 112503 (2020). [Invited Article]
19. G.V. Vogman, J.H. Hammer, U. Shumlak, and W.A. Farmer. Two-fluid and kinetic transport physics of Kelvin-Helmholtz instabilities in nonuniform low-beta plasmas. *Physics of Plasmas* **27**, 102109 (2020). [Editor's Pick Article]
20. E.L. Claveau, U. Shumlak, B.A. Nelson, E.G. Forbes, A.D. Stepanov, T.R. Weber, Y. Zhang, and H.S. McLean. Plasma Exhaust in a Sheared-Flow-Stabilized Z Pinch. *Physics of Plasmas* **27**, 092510 (2020).
21. E.G. Forbes and U. Shumlak. Spatio-temporal ion temperature and velocity measurements in a Z pinch using fast-framing spectroscopy. *Review of Scientific Instruments* **91**(8), 083104 (2020).
22. J.M. Mitrani, D.P. Higginson, Z.T. Draper, J. Morrell, L.A. Bernstein, E.L. Claveau, C.M. Cooper, E.G. Forbes, R.P. Golingo, B.A. Nelson, A.E. Schmidt, A.D. Stepanov, T.R. Weber, Y. Zhang, U. Shumlak, and H.S. McLean. Measurements of temporally- and spatially-resolved neutron production in a sheared-flow stabilized Z-pinch. *Journal of Nuclear Instruments and Methods in Physics Research Section: A* **947**, 162764 (2019).
23. E.G. Forbes, U. Shumlak, H.S. McLean, B.A. Nelson, E.L. Claveau, R.P. Golingo, D.P. Higginson, J.M. Mitrani, A.D. Stepanov, K.K. Tummel, T.R. Weber, and Y. Zhang. Progress Towards a Compact Fusion Reactor using the Sheared-Flow Stabilized Z-Pinch. *Fusion Science and Technology* **75**(7), 599 (2019). [Invited Article]
24. K.K. Tummel, D.P. Higginson, A.J. Link, A.E.W. Schmidt, D.T. Offermann, D.R. Welch, R.E. Clark, U. Shumlak, B.A. Nelson, R.P. Golingo, and H.S. McLean. Kinetic simulations of

- sheared flow stabilization in high-temperature Z-pinch plasmas. *Physics of Plasmas* **26**, 062506 (2019). [Invited Article]
25. Y. Zhang, U. Shumlak, B.A. Nelson, R.P. Golingo, T.R. Weber, A.D. Stepanov, E.L. Claveau, E.G. Forbes, Z.T. Draper, J.M. Mitrani, H.S. McLean, K.K. Tummel, D.P. Higginson, and C.M. Cooper. Sustained neutron production from a sheared-flow stabilized Z-pinch. *Physical Review Letters* **122**, 135001 (2019). [Featured Article]
 26. A. Ho, I.A.M. Datta, and U. Shumlak. Physics-Based-Adaptive Plasma Model for High-Fidelity Numerical Simulations. *Frontiers in Physics* **6**, 105 (2018).
 27. G.V. Vogman, U. Shumlak, and P. Colella. Conservative fourth-order finite-volume Vlasov-Poisson solver for axisymmetric plasmas in cylindrical (r, v_r, v_θ) phase space coordinates. *Journal of Computational Physics* **373**, 877 (2018).
 28. U. Shumlak, B.A. Nelson, E.L. Claveau, E.G. Forbes, R.P. Golingo, M.C. Hughes, R.J. Oberto, M.P. Ross, and T.R. Weber. Increasing plasma parameters using sheared flow stabilization of a Z-pinch. *Physics of Plasmas* **24**, 055702 (2017). [Invited Article]
 29. M.P. Ross and U. Shumlak. Digital holographic interferometry employing Fresnel transform reconstruction for the study of flow shear stabilized Z-pinch plasmas. *Review of Scientific Instruments* **87**, 103502 (2016).
 30. E.M. Sousa and U. Shumlak. A blended continuous – discontinuous finite element method for solving the multi-fluid plasma model. *Journal of Computational Physics* **326**, 56 (2016).
 31. S.T. Miller and U. Shumlak. A multi-species 13-moment model for moderately collisional plasmas. *Physics of Plasmas* **23**, 082303 (2016).
 32. E.M. Sousa, G. Lin, and U. Shumlak. Uncertainty quantification of the GEM challenge magnetic reconnection problem using the multilevel Monte Carlo method. *International Journal for Uncertainty Quantification* **5**, 327 (2015).
 33. S.D. Knecht, R.P. Golingo, B.A. Nelson, and U. Shumlak. Calculation of the equilibrium evolution of the ZaP Flow Z-Pinch using a four-chord interferometer. *IEEE Transactions on Plasma Science* **43**, 2469 (2015).
 34. G.V. Vogman, P. Colella, and U. Shumlak. Dory-Guest-Harris instability as a benchmark for continuum kinetic Vlasov-Poisson simulations of magnetized plasmas. *Journal of Computational Physics* **277**, 101 (2014).
 35. S.D. Knecht, W. Lowrie, and U. Shumlak. Effects of a conducting wall on Z-pinch stability. *IEEE Transactions on Plasma Science* **42**, 1531 (2014).
 36. E. Kansa, U. Shumlak, and S. Tsynkov. Discrete Calderon's Projections on Parallelepipeds and their Application to Computing Exterior Magnetic Fields for FRC Plasmas. *Journal of Computational Physics* **234**, 172 (2013).
 37. U. Shumlak, J. Chadney, R.P. Golingo, D.J. Den Hartog, M.C. Hughes, S.D. Knecht, W. Lowrie, V.S. Lukin, B.A. Nelson, R.J. Oberto, J.L. Rohrbach, M.P. Ross, and G.V. Vogman. The Sheared-Flow Stabilized Z-Pinch. *Fusion Science and Technology* **61** (1t), 119 (2012).
 38. E.T. Meier and U. Shumlak. A general nonlinear fluid model for reacting plasma-neutral mixtures. *Physics of Plasmas* **19**, 072508 (2012).
 39. E.T. Meier, A.H. Glasser, V.S. Lukin, and U. Shumlak. Modeling open boundaries in dissipative MHD simulation. *Journal of Computational Physics* **231**, 2963 (2012).

40. U. Shumlak, R. Lilly, N. Reddell, E. Sousa, and B. Srinivasan. Advanced physics calculations using a multi-fluid plasma model. *Computer Physics Communications* **182**, 1767 (2011).
41. G.V. Vogman and U. Shumlak. Deconvolution of Stark broadened spectra for multi-point density measurements in a flow Z-pinch. *Review of Scientific Instruments* **82** (10), 0034-6748 (2011).
42. B. Srinivasan and U. Shumlak. Analytical and computational study of the ideal full two-fluid plasma model and asymptotic approximations for Hall-MHD. *Physics of Plasmas* **18**, 092113 (2011).
43. W. Lowrie, V.S. Lukin, and U. Shumlak. *A priori* mesh quality metric error analysis applied to a high-order finite element method. *Journal of Computational Physics* **230**, 5564 (2011).
44. B. Srinivasan, A. Hakim, and U. Shumlak. Numerical methods for two-fluid dispersive fast MHD phenomena. *Communications in Computational Physics* **10**, 183 (2011).
45. J. Loverich, A. Hakim, and U. Shumlak. A discontinuous Galerkin method for ideal two-fluid plasma equations. *Communications in Computational Physics* **9**, 240 (2011).
46. R.P. Golingo, U. Shumlak, and D.J. Den Hartog. Zeeman splitting measurements in a high-temperature plasma. *Review of Scientific Instruments* **81**, 126104 (2010).
47. E.T. Meier, V.S. Lukin, and U. Shumlak. Spectral element spatial discretization error in solving highly anisotropic heat conduction equation. *Computer Physics Communications* **181**, 837 (2010).
48. W. Song and U. Shumlak. Ultrasonically-Aided Electrospray Source for Charged Particles Approaching Monodisperse Distributions. *Journal of Propulsion and Power* **26** (2), 353 (2010).
49. U. Shumlak, C.S. Adams, J.M. Blakely, B.-J. Chan, R.P. Golingo, S.D. Knecht, B.A. Nelson, R.J. Oberto, M.R. Sybouts, and G.V. Vogman. Equilibrium, flow shear and stability measurements in the Z-pinch. *Nuclear Fusion* **49** (7), 075039 (2009).
50. U. Shumlak, J.M. Blakely, B.-J. Chan, R.P. Golingo, S.D. Knecht, B.A. Nelson, R.J. Oberto, M.R. Sybouts, G.V. Vogman, and D.J. Den Hartog. Stabilization in the ZaP Flow Z-Pinch. *Journal of Fusion Energy* **28** (1-2), 208 (2009).
51. S.D. Knecht, U. Shumlak, B.-J. Chan, R.P. Golingo, and B.A. Nelson. Results of the Inner Electrode Modification on the ZaP Flow Z-Pinch. *Journal of Fusion Energy* **28** (1-2), 175 (2009).
52. K.A. Munson, U. Shumlak, and B.A. Nelson. Extreme Ultraviolet Light Production from a ZaP Flow Z-Pinch Xenon Plasma. *Journal of Micro/Nanolithography, MEMS, and MOEMS (JM3)* **7** (1), 013003-1-9 (2008).
53. W. Song and U. Shumlak. Charged Nanoparticle Source for High Thrust Level Colloid Thrusters. *Journal of Propulsion and Power* **24** (1), 139 (2008).
54. U. Shumlak, B.A. Nelson, C.S. Adams, B.-J. Chan, R.P. Golingo, S.D. Knecht, K.A. Munson, and D.J. Den Hartog. Stabilization in the ZaP Flow Z-Pinch. *Journal of Fusion Energy* **27** (1-2), 111-114 (2008).
55. U. Shumlak, B.A. Nelson, and B. Balick. Plasma Jet Studies via the Flow Z-Pinch. *Astrophysics and Space Science* **307** (1-3), 41 (2007).

56. A. Hakim and U. Shumlak. Two-fluid physics and field-reversed configurations. *Physics of Plasmas* **14** (5), 055911 (2007). [Invited Article]
57. U. Shumlak, B.A. Nelson, C.S. Adams, D.J. Den Hartog, R.P. Golingo, S.L. Jackson, S.D. Knecht, J.B. Pasko, and D.T. Schmuland. Equilibrium Evolution in the ZaP Flow Z-Pinch. *Journal of Fusion Energy* **26** (1-2), 185-189 (2007).
58. A. Hakim, J. Loverich, and U. Shumlak. A high resolution wave propagation scheme for ideal two-fluid plasma equations. *Journal of Computational Physics* **219** (1), 418 (2006).
59. J. Loverich and U. Shumlak. Non-linear two-fluid study of $m=0$ sausage instabilities in an axisymmetric Z-pinch. *Physics of Plasmas* **13** (7), 082310 (2006).
60. S.L. Jackson and U. Shumlak. Abel inversion of a holographic interferogram for determination of the density profile of a sheared-flow Z-pinch. *Review of Scientific Instruments* **77**, 083502 (2006).
61. M. Selwa, S.K. Solanki, K. Murawski, T.J. Wang, and U. Shumlak. Numerical Simulations of Impulsively Generated Vertical Oscillations in a Solar Coronal Arcade Loop. *Astronomy and Astrophysics* **454** (2), 653 (2006).
62. R.P. Golingo, U. Shumlak, and B.A. Nelson. Formation of a sheared flow Z pinch. *Physics of Plasmas* **12** (6), 62505 (2005).
63. D.J. Den Hartog, R.P. Golingo, S.L. Jackson, B.A. Nelson, and U. Shumlak. The ZaP Flow Z-Pinch: Plasma Flow Shear and Stability. *Fusion Science and Technology* **47** (1T), 134 (2005).
64. J. Loverich and U. Shumlak. A discontinuous Galerkin method for the full two-fluid plasma model. *Computer Physics Communications* **169** (3), 251 (2005).
65. U. Shumlak and J. Loverich. Approximate Riemann solver for the two-fluid plasma model. *Journal of Computational Physics* **187** (2), 620 (2003).
66. U. Shumlak, B.A. Nelson, R.P. Golingo, S.L. Jackson, E.A. Crawford, and D.J. Den Hartog. Sheared flow stabilization experiments on the ZaP flow Z-pinch. *Physics of Plasmas* **10** (4), 1683 (2003). [Invited Article]
67. R.P. Golingo and U. Shumlak. Spatial deconvolution technique to obtain velocity profiles from chord integrated spectra. *Reviews of Scientific Instruments* **74** (4), 2332 (2003).
68. U. Shumlak, R.P. Golingo, B.A. Nelson, and D.J. Den Hartog. Evidence of stabilization in the Z pinch. *Physical Review Letters* **87** (20), 205005 (2001).
69. U. Shumlak and T.R. Jarboe. Stable high beta spheromak equilibria using concave flux conservers. *Physics of Plasmas* **7** (7), 2959 (2000).
70. J.H. Degnan, M.L. Alme, B.S. Austin, J.D. Beason, S.K. Coffey, D.G. Gale, J.D. Graham, J.J. Havranek, T.W. Hussey, G.F. Kiuttu, B.B. Kreh, F.M. Lehr, R.A. Lewis, D.E. Lileikis, D. Morgan, C.A. Outten, R.E. Peterkin, Jr., D. Platts, N.F. Roderick, E.L. Ruden, U. Shumlak, G.A. Smith, W. Sommars, and P.J. Turchi. Compression of Plasma to Megabar Range using Imploding Liner. *Physical Review Letters* **82** (13), 2681 (1999).
71. U. Shumlak and T.R. Jarboe. Higher mode stability in spheromak equilibria. *Physics of Plasmas* **6** (11), 4382 (1999).
72. U. Shumlak and N.F. Roderick, Mitigation of the Rayleigh-Taylor instability by sheared axial flows. *Physics of Plasmas* **5** (6), 2384 (1998).

73. O.S. Jones, U. Shumlak, D.S. Eberhardt. An Implicit Scheme for Non-Ideal Magnetohydrodynamics. *Journal of Computational Physics* **130**, 231 (1997).
74. C.W. Hartman, J.L. Eddleman, A.A. Newton, L.J. Perkins, and U. Shumlak. Magnetic Confinement Fusion and the Continuous-Flow Pinch. *Plasma Physics and Controlled Fusion* **17** (5), 267 (1996).
75. U. Shumlak and C.W. Hartman. Sheared Flow Stabilization of the $m=1$ Kink Mode in Z-Pinches. *Physical Review Letters* **75** (18), 3285 (1995).
76. U. Shumlak, T.W. Hussey, and R.E. Peterkin, Jr. Three-Dimensional Magnetic Field Enhancement in a Liner Implosion System. *IEEE Transactions on Plasma Science* **23** (1), 83 (1995).
77. T.W. Hussey, N.F. Roderick, U. Shumlak, R.B. Spielman, and C. Deeney. A heuristic model for the non-linear Rayleigh-Taylor instability in fast Z-pinches. *Physics of Plasmas* **2** (6), 2055 (1995).
78. J.H. Degnan, F.M. Lehr, J.D. Beason, G.P. Baca, D.E. Bell, A.L. Chesley, S.K. Coffey, D. Dietz, D.B. Dunlap, S.E. Englert, T.J. Englert, D.G. Gale, J.D. Graham, J.J. Havranek, C.D. Holmberg, T.W. Hussey, R.A. Lewis, C.A. Outten, R.E. Peterkin, D.W. Price, N.F. Roderick, E.L. Ruden, U. Shumlak, G.A. Smith, and P.J. Turchi. Electromagnetic Implosion of Spherical Liners. *Physical Review Letters* **74** (1), 98 (1995).
79. C.W. Hartman, J.L. Eddleman, R. Moir, and U. Shumlak. The Flow-Through Z-Pinch for Fusion Energy Production. *Fusion Technology* **26** (3), 1203 (1994).
80. U. Shumlak, T.K. Fowler, and E.C. Morse. Rotational effects on the $m=1$ magnetohydrodynamic instability in spheromaks. *Physics of Plasmas* **1** (3), 643 (1994).

Patents

1. U. Shumlak, B.A. Nelson, and E.T. Meier, "Apparatus and Method for Extended Plasma Confinement", Utility Patent US 11,758,640 B2, September 12, 2023.
2. E.T. Meier, B.A. Nelson, and U. Shumlak, "Electrode Configuration for Extended Plasma Confinement", Utility Patent US 11,744,001 B2, August 29, 2023.
3. U. Shumlak, B.A. Nelson, and R.P. Golingo, "Z-Pinch Plasma Confinement System having Intermediate Electrode and Methods for Use", Utility Patent US 11,581,100, February 14, 2023.
4. U. Shumlak, H.S. McLean, and B.A. Nelson, "Plasma Confinement System with Outer Electrode Having Liquifiable Material and Methods for Use", Utility Patent US 11,219,117 B2, January 4, 2022.
5. U. Shumlak, R.P. Golingo, and B.A. Nelson, "Plasma-Based EUV Light Source," Utility Patent US 7,825,391 B2, November 2, 2010.
6. U. Shumlak, R.P. Golingo, and B.A. Nelson, "Plasma-Based EUV Light Source," Utility Patent US 7,372,059 B2, May 13, 2008.