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Summary

Over two decades of experience as an Aerospace Engineer producing analytical and computational techniques to solve complex problems involving spacecraft mission design, trajectory planning, orbit analysis and control, trajectory optimization, orbit maneuver design, and formation flying. Led multiple projects where I directed and oversaw the activities of large teams, setting appropriate deadlines and priorities in conjunction with management, to bring to fruition complex spacecraft mission design tasks including the development of new and innovative flight trajectories with special emphasis on those that best met complex science goals, state-of-the-art formation flying algorithms including advanced close approach assessment methods to ensure spacecraft safety, and associated orbit maneuver designs that achieved the required orbit control using optimal amounts of fuel. I have brought these techniques, algorithms, and methods to maturity in the form of automated ground systems that support missions from launch/early orbit operations, through ascent, routine operations, and retirement. Received numerous awards for engineering achievement and project management efforts leading teams on pre-launch development and operational support for numerous NASA missions, including WMAP, ACE, JWST, and MMS, and for mentoring and public outreach.

Education

- Doctor of Philosophy, Physics, University of Maryland, 2005
- Masters of Science, Physics, Carnegie Mellon University, 1989
- Bachelor of Science, Physics, Pennsylvania State University, 1987

Dissertation

"Modeling Extended Fluid Objects in General Relativity"

Committee: Charles W. Misner (Chairman/Advisor, Physics Department), Dieter Brill (Physics Department), David Levermore (Mathematics Departement), M. Coleman Miller (Astronomy Department), Ho Jung Paik (Physics Department)

The purpose of the dissertation was to introduce and explore the notion of modeling extended fluid objects in numerical general relativity. These extended fluid objects, called Fat Particles, are proxies for compact hydrodynamic objects. Unlike full hydrodynamic models, Fat Particles assume that the details of the matter distribution are less important than the gross motion of their center of mass. The approach starts with a continuum variational principle that yields the desired hydrodynamic and gravitational equations for ideal fluids. Application of a numerical technique based on Smoothed Particle Hydrodynamics (SPH), results in a discretized action. Subsequent variations yield a set of consistent discrete equations of motion that give semi-analytic corrections to the Fat Particle's motion due to its extended nature. Applying these equations to the motion of a finite-sized object (e.g. white dwarf) about a massive black hole results in a universal scaling law that describes the phase shift, relative to a test particle, that is independent of its size, shape, and distribution. Changes to the motion, due to finite-size effects, eventually dominates those due to radiation damping, and have important consequences in determining candidate signal structure for gravitational wave observatories.

Professional Experience

September 2006 – present
Aerospace Engineer, Navigation and Mission Design Branch (NMDB), NASA, Goddard Spaceflight Center

- ***MMS Flight Dynamics Lead (April 2010-present)*** Provided leadership and oversight for the work assignments of over 20 professionals in the design and development of the Magnetospheric MultiScale

(MMS) spacecraft mission design & mission design activities. Responsible for managing over $3 million/year budget. Set priorities and deadlines, organized personnel into discipline-oriented groups based on ability and 'area of passion', designated group leads, delegated responsibility to them to decide how to execute the work, provided high level programmatic and technical assistance, and held them accountable so that deliveries were on time and within budget. Interfaced with the MMS GNC Lead and helped with management complex GNC analysis products and services. These included an analysis of the science instruments fields of view and the GNC sensor suite capabilities and control capabilities (delta-H controller) to determine the best way to manage gravity-gradient torque; development of a detail concept of operations for performing formation flying maintenance maneuvers given the GNC delta-V controller; and the development of the materials for proper situational awareness for command authorization meetings (CAMs) and the implementation of an automated system called AutoCAM for producing a consolidated report for review at the CAMs. Directed requirements and negotiated cost for launch/early orbit support operations from the NASA GSFC Flight Dynamics Facility (FDF). Worked directly with the MMS Project Manager, Deputy Project Manager, and Mission Systems Engineer to determine launch vehicle support and spacecraft mission design that best met MMS science goals based on the implications to the Level 1 requirements and spacecraft design. Invited to speak at all MMS Science Working Teams meetings. Worked directly with PI and Deputy PI, as well as the Project and Program Scientists from MMS and THEMIS, to determine how to achieve coincident science observations between the MMS and THEMIS spacecraft. Provided an assessment of risks involved, including impacts to launch vehicle schedule and flight profile (atomic oxygen concern for the SDP instrument and aerothermal and solar heating for the ADP instrument), fuel usage, and overall ability of the MMS formation to meet science goals (e.g. reconnection versus depolarization front). Areas of technical expertise include development of state-of-the-art analysis tools for mission design based on VOP methods, formation flying and trajectory optimization, orbit control strategies and orbit maneuver design, large scale numerical simulations, error modeling and propagation for close approach risk assessment and spacecraft safety, systems engineering analysis of science requirements, and analysis of onboard navigation performance of the Navigator/GEONS system.

- ***JWST Flight Dynamics Lead (January 2007-April 2010)*** Responsible for providing flight dynamics support for JWST from post-SRR through mission CDR. Acted as JWST liaison to launch vehicle flight design group at Arianespace. In this capacity, was responsible for setting the launch profile requirements and for ensuring mission safety of JWST during its transfer trajectory. Worked with ground system development staff and personnel from the Space Telescope Science Institute to develop a concept of operations taking into account JWST field of view, observation schedules, momentum unloads, and fuel budget. Implemented a combination of analytic and numeric techniques that adapted restricted three-body theory to automate the modeling of the mission trajectory from launch to disposal. Developed a large scale Monte Carlo analysis of the use of an extended Kalman filter for JWST spacecraft navigation taking into account the significant solar radiation pressure force due to the spacecraft's large sun-shield. Worked with Mission Systems Engineering Team as a consultant on topics that included the stability of the Arianespace first stage control system given the JWST center of mass, analysis of the amount of stray light tolerable given thermal requirements and how that limited the orbit size, and the implications on the midcourse maneuvers from the known limitations of the Northrup Grumman Secondary Combustion Augmentation Thruster (SCAT) design.
- ***Branch Consultant and Mentor (September 2006 – present)*** Developed the Box Algorithm used for launch window development on JWST and DISCOVER and trained branch members on its use. Promoted the use of analytic techniques based on simple analytic models to improve branch support and lower cost and turnaround time of analysis (e.g., SWM76 used on launch window, and mission design on MMS). Conceived, analyzed, and performed concept development for new GNC related technologies including the application of differential geometric techniques to the Spin Axis Prediction tool for trending and control of the MMS attitude. Mentored and consulted with a junior engineer on additional analyses and comparison techniques of the GNOME computer vision technique for use in spacecraft rendezvous and docking. Was approached directly by LISA, TESS, and MEMEX science and project personnel for consultation on their respective future mission concepts. Served on multiple review panels, both at the peer level and for Code 300. These reviews included ARTEMIS extended mission concept; ASTRE proposal and future mission concept; GLORY, OCO, and LDCM ascent reviews; GOES M, N, O Operational Readiness Reviews. Currently supporting Code 500 PDL

Training. Conceived the PDLSat Case Study training tool, authored the narrative, tailored the classroom exercises to the each individual workshop and served as an instructor in same.

February 1998 – September 2006
Systems Engineer (98-01) & Chief Scientist (01-06), a.i. solutions, Inc., Lanham, MD

- Developed new techniques for analyzing the probability of collision between spacecraft and resident space objects to determine spacecraft safety, including the analysis of the 'error in the error' for covariance computations and for propagating covariance data through the presence of an orbital maneuver.
- Development of an object-oriented spacecraft navigation system and the subsequent application to precise orbit determination for both the Aqua and Aura spacecraft. Meter-level accuracy achieved using a combination of ground- and space-based range and Doppler measurements.
- Led analysis, design, and development of a state-of-the-art constellation coverage tool (Indra/COV) that allowed for the calculation and optimization of a variety of coverage metrics and the visualization of the data obtained.
- Led research and development into trajectory optimization methods for planning spacecraft trajectories. Focus centered on Primer Vector formalism, a variational technique.
- Led trajectory planning and mission design work on the Wilkinson Microwave Anisotropy Probe (WMAP) mission involving a phasing-loop gravity-assist transfer to a Lissajous orbit about the L2 Sun-Earth Lagrange point. Developed algorithms for producing new launch blocks and analyzing the stability of the resulting solutions. Implemented a fuel-minimized Monte Carlo analysis of the impact of launch vehicle dispersions. Interfaced with mission project and sub-system leads. Implemented an assessment technique for classifying the risk associated with each launch date.
- Work on basic formation flying concepts for missions performing spatial resolution of the Earth's magnetic field, generating a synthetic aperture radar imaging, and related measurements. Analysis of the Clohessy-Witlshire equations and their generalization to eccentric orbits and optimal control strategies to maintain and reconfigure the formation.

August 1990 – February 1998
Senior Member of the Technical Staff, Computer Sciences Corporation, Systems Sciences Division, Calverton, MD

- Lead designer for the Advanced Composition Explorer (ACE) mission. Designed 3-impulse transfer trajectory from low-Earth parking orbit to Lissajous orbit. Determined optimal Lissajous orbit parameters and designed the Lissajous insertion maneuver. Participated in the spacecraft design process. Performed error and contingency analysis. Analyzed coupling between orbit and attitude dynamics during the maneuver execution.
- Lead designer on encounter of the Clementine spacecraft with the asteroid Geographos. Co-designer on the phasing loop and lunar mapping phases and lead on maneuver execution error analysis.
- Designed and implemented mathematical models of spacecraft orbital dynamics, attitude descriptions, impulsive and finite maneuver modeling, targeting and optimization, and deep-space mission design techniques involving double lunar swingby cycles, lunar back flips, halo and Lissajous orbits.

Academic Experience

February 1997 – November 2005
Researcher, Binary Neutron Star Collaboration, Doctoral Program University of Maryland Physics Department

- Responsible for the derivation, development and implementation of the algorithms needed for computer modeling of strong-field back-reacting general relativistic fluids to calculate gravitational radiation profiles for use by the LIGO project. Developed tensor++ package, a set of object-oriented generic tensor and tensor-field objects in C++ used for calculations of particle and field motions. Derived a fully relativistic self-gravitating smoothed particle hydrodynamics (SPH) theory based on an earlier derived continuum Lagrange variational principle.

January 1996 – February 1997

Researcher, Molecular Beam Epitaxy and Nonequilibrium Growth Studies, Doctoral Program University of Maryland Physics Department

- Development and implementation of Monte Carlo code to model epitaxial growth of FCC metals away from equilibrium. Emphasis on the morphology and height-height correlations of the mounds formed during various growth scenarios. Some work on dynamic renormalization group.

March 1989 – August 1990

Researcher, Computer Models of Phase Transitions, Doctoral Program Carnegie Mellon University Physics Department

- Wrote and studied computer models of phase transitions using advanced Monte Carlo techniques for a variety of physical systems. These include: 2-dimensional Ising model on square and triangular lattices, non-equilibrium Ising model, and 2-dimensional dimer model on a triangular lattice.

Mathematical and Computational Skills

- Extensive programming experience developing scientific and engineering simulations:
  - Numerical integration of ordinary and partial differential equations
  - Classical indirect and direct optimization techniques
  - Stochastic techniques and cellular automata
  - Kalman filtering and optimal estimation
  - Computational fluid dynamics
  - Coordinate transformations between standard inertial coordinate frames and local (moving) coordinates
  - Eigenvalue/eigenvector decomposition of launch vehicle, maneuver execution, and orbit determination covariance data
  - Stability analysis of trajectories and their application to maneuver targeting and related two-point boundary value problems
  - Application of Fourier transforms to state transition matrix modeling
  - Analysis of corrections to measurement models due to general relativistic effects
  - Design and analysis of trajectories in the restricted three-body problem and its application to libration point missions
  - Analysis of maneuver strategies for transfer trajectories for lunar encounters, libration point orbits, and highly elliptical orbits
  - Variational methods in mechanics and related topics in differential geometry as applied to celestial mechanics
- Programming languages: C/C++, FORTRAN, Perl, Java, Matlab, Maxima, Python, some Lisp
- Tools: Matlab, Maple, Mathematica, Maxima

Awards

- NASA Agency Honor Award for Exceptional Leadership on the Magnetospheric Multiscale (MMS) Mission
- NASA Robert H. Goddard Award for Exceptional Achievement in Engineering for the James Webb Space Telescope, 2010
- NASA Robert H. Goddard Award for Exceptional Achievement in Mentoring, 2009
- NASA Special Act Team Award for word on the FDSS Contract Source Evaluation Board 2009
- NASA Group Achievement Award for Contributions to the NASA Robotic Conjunction Assessment Team 2009
- NASA Group Achievement Award for Contributions to the James Webb Space Telescope 2009
- NASA Group Achievement Award for Contributions to Aura Project 2005
- NASA Achievement Award for Outstanding Contributions to the development and launch of the Aura Mission 2004

- NASA Group Achievement Award Center of Excellence for Microwave Anisotropy Probe (MAP) 2002
- NASA Group Achievement Award for the Microwave Anisotropy Probe (MAP) development and launch 2002
- NASA Group Achievement Award for the Microwave Anisotropy Probe (MAP) Monte Carlo Development and Analysis 2001
- NASA Group Achievement Award for the Microwave Anisotropy Probe (MAP) Trajectory Design and Development 2001
- NASA Group Achievement Award for the Advance Composition Explorer (ACE) design, development and launch 1998
- Flight Dynamics Operation Achievement Award for contributions to the WIND mission, 1996
- CSC Team Technical Excellence Award, for support of Clementine Mission, 1994
- CSC President's Excellence Award, for support of Clementine Mission, 1994
- NASA Special Act Group Award. DSPSE (Clementine) Lunar Orbit Mission Operations Support Team, 1994

Professional Associations

- American Association of Physics Teachers – life member
- Chesapeake AAPT member
- American Physical Society
- Society of Physics Students and Sigma Pi Sigma Physics Honor Society
- Pi Mu Epsilon Math Society

Publications

- Weekly articles on Computing & Philosophy, Economics, and Physics on Blog Wyrm (http://aristotle2digital.blogwyrm.com; http://commoncents.blogwyrm.com; http://underthehood.blogwyrm.com; http://www.blogwyrm.com)
- *Vesta's Missing Moons: Comprehensive Search for Natural Satellites of Vesta by the Dawn Spacecraft*, L. A. McFadden, D. Skillman, N. Memarsadeghi, J. Y. Li, S. Joy, C. Polanskey, M. Rayman, M. Sykes, P. Tricarico, E. Palmer, D. O'Brien, S. Mottola, U. Carsenty, M. Mutchler, B. McLean, S. Schröder, N. Mastrodemos, C. Schiff, U. Keller, A. Nathues, P. Gutierrez-Marques, C. Raymond, C. T. Russell, (submitted to Icarus Jan. 2015)
- *Magnetospheric Multiscale Science Mission Profile and Operations*, S. A. Fuselier, W. S. Lewis, C. Schiff, R. Ergun, J. L. Burch, S. M. Petrinec, K. J. Trattner, Space Sci Rev, Sept 2014, DOI 10.1007/s11214-014-0087-x
- *Magnetospheric MultiScale (MMS) System Manager*, C. Schiff, F. Maher, Sean Henely, D. Rand, Ground System Architecture Worshop, Los Angeles, 2014
- *Getting the Most from Simple Models*, Systems Engineering Seminary, Goddard Space Flight Center, *http://mediastream.ndc.nasa.gov/public2/webvid/SES/2013/SES20130409/default.html*
- *Monte Carlo Simulations of the Formation Flying Dynamics for the Magnetospheric Multiscale (MMS) Mission*, C. Schiff and E. Dove, 22nd International Symposium on Space Flight Dynamics Sao Jose dos Campos, Brazil, 2011
- *Adapting Covariance Propagation to Account for the Presence of Modeled and Unmodeled Maneuvers*, C. Schiff, AIAA/AAS Astrodynamics Specialist Conference Keystone, CO, 2006
- *Modeling Extended Fluid Objects in General Relativity*, C. Schiff, Doctoral Disstertation, 2005
- *Operational Experiences in Planning and Reconstructing Aqua Inclination Maneuvers*, D. Rand, J. Reilly, C. Schiff, 18th International Symposium on Space Flight Dynamics Munich, Germany, 2004
- *CALIPSO's Mission Design: Sun-Glint Avoidance Strategies*, L. Mailhe, C. Schiff, J. Stadler, AAS/AIAA Space Flight Mechanics Meeting Maui, Hawaii, 2004
- *Initialization of Formation Flying Using Primer Vector Theory*, L. H. Mailhe, C. Schiff, D. Folta, Centre National d'Etudes Spatiales Toulouse, France, 2002

- *Implementation of An Object Oriented Design for Orbit Determination using FreeFlyer®*, T. Tran, C.Schiff, Core Technologies for Space Systems Conference Colorado Springs, Colorado, 2002
- *A Preliminary Study for a Tetrahedron Formation: Quality Factors and Visualization*, J.J. Guzman and C. Schiff, AIAA/AAS Astrodynamics Specialists Conference Monterey, California, 2002
- *Stationkeeping Approach for the Microwave Anisotropy Probe* , D. Rohrbaugh, C. Schiff , AIAA/AAS Astrodynamics Specialists Conference Monterey, California, 2002
- *The Double Lunar Swingby of the MMS Mission*, A. Edery and C. Schiff, 16th International Symposium on Space Flight Dynamics Pasadena, California, 2001
- *Indra/COV: a new tool for optimization of constellations coverage statistics*, C. Schiff, L. Mailhe, 16th International Symposium on Space Flight Dynamics Pasadena, California, 2001
- *Formation Flying in Highly Elliptical Orbits: Initializing the Formation*, L. Mailhe, C. Schiff, and S. Hughes, 15th International Symposium on Space Flight Dynamics Biarritz, France, 2001
- *Formation Flying in Elliptical Orbits*, C. Schiff, D. Rohrbaugh, and J. Bristow, IEEE Aerospace Conference Big Sky, Montana, 2000
- *Risk Mitigation Using Monte Carlo*, C. Schiff, S. Good, and D. Rohrbaugh, AAS/AIAA Space Flight Mechanics Meeting Clearwater, Florida, 2000