Curriculum Vitae of Dr. Behnam Seyed-Mahmoud

CONTACT INFORMATION

Behnam Seyed-Mahmoud, P.Geo.
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EDUCATION

Ph.D., Physics, 1999: York University, Toronto, Ontario, Canada
Thesis: Elliptical Instability in Rotating Fluid Shells
Supervisor: Dr. Keith Aldridge
Theory, computational and experimental work in fluid dynamics

M.Sc., Geophysics, 1994: Memorial University, St. John's, Newfoundland, Canada
Thesis: Wobble/Nutation of a Rotating Ellipsoidal Earth with Liquid Outer Core
Supervisor: Dr. Michael Rochester
Theoretical and computational work in fluid dynamics

B.Sc., Physics, 1991: The University of Lethbridge, Lethbridge, Alberta, Canada

PROFESSIONAL ACTIVITIES AND AFFILIATIONS

P.Geo. (Professional Geoscientist)
Member of APEGA, the Association of Professional Engineers and Geoscientists of Alberta
2013- Present

Adjunct Assistant Professor
2005-2013
Department of Physics and Astronomy
The University of Lethbridge

Adjunct Member
2006-2009
Shanghai Astronomical Observatory
Chinese Academy of Science
Shanghai 200030, China

Member of the International Astronomical Union (IAU)
Member of the American Geophysical Union (AGU)
Member of the Canadian Geophysical Union (CGU)

RESEARCH INTERESTS

My research deals with theoretical/computational and experimental studies in rotating fluids with applications to planetary and stellar interiors.

I am interested in predicting the frequencies of the Earth's normal modes, especially those of wobble and nutation for which the observed frequencies are known. By matching the predicted and observed frequencies and adjusting the Earth models for a better fit, we strive to improve our knowledge of the material properties of the Earth's interiors and hence help predict the future states of our planet.

We also investigate the elliptical instability developed in the planetary fluid cores, as a result of the gravitational pull of nearby bodies, in the nonlinear regime. The onset of the elliptical instability has been studied extensively using the linearized equations. It is suggested that the instability may have energized and sustained the geodynamo. Recently we have proposed that the Mars' dynamo, which was responsible for the magnetic field frozen in the planet's crust, was also energized by an elliptical instability developed as a result of the gravitational pull of a giant asteroid orbiting Mars early in the planet's history. Eventually the asteroid crashed into Mars and the planet's dynamo diminished. A planetary dynamo based on elliptical instability has never been established. Our goal is to first solve the nonlinear equations of the instability. This will yield the growth rate of the instability and hence the amplitude of the motion, in the nonlinear regime. We will then derive a numerical planetary dynamo based on the instability. In the absence of convection in the planetary fluid cores the dynamo theory based on the elliptical instability offers an alternative explanation for the origin of the planetary magnetic fields.
I am also interested in the experimental studies of these phenomena. These studies complement the theoretical/computational studies.

RESEARCH GRANTS

University of Lethbridge Start-up Fund, (2014), $10,000
NSERC Discovery Grant (2008), $17,500/year for 7 years (Originally granted for 5 years then extended for two years)
Project Title: Dynamics of the Earth and Planetary Deep Interiors

Canadian Space Agency (CSA) (2007), $250,000, of which I received $9000
Project: Concept Study for the 'High Resolution Magnetic Observations of Mars Enabled by Nanosatellite Technology (MOMENT)' project
A collaborative project with scientists from University of Toronto, McGill University, University of Calgary, York University and University of Lethbridge

NSERC Discovery Grant (2005), $21,400/year for 3 years
Project Title: Oscillatory Dynamics of Rotating Fluid Bodies: Applications to Earth and Stellar Interiors

University of Lethbridge Research Fellowship (ULRF) (2005), $4,500
Project Title: Oscillatory Dynamics of Rotating Stars

University of Lethbridge Research Fellowship (ULRF) (2003), $4,500
Project Title: Three-Potential-Description of the Oscillatory Dynamics of Rotating Fluids

REFEREED JOURNAL PUBLICATIONS

Behnam Seyed-Mahmoud, Ali Moradi, Dynamics of the Earth's fluid core: implementation of a Clairaut coordinate system, 2013, *Physics of the Earth and Planetary Interiors,(in press)* http://dx.doi.org/10.1016/j.pepi.2013.11.007

Behnam Seyed-Mahmoud, Ali Moradi, Inertial modes of a realistic fluid core model, 2013, *Physics of the Earth and Planetary Interiors,* (submitted, under revision)

Behnam Seyed-Mahmoud and Mark Tipper, Gravity and inertial modes of rotating stars, 2008, *Astrophysical and Geophysical Fluid Dynamics*, 102(4): 383–395

J. Arkani-Hamed, B. Seyed-Mahmoud, K. Aldridge and R. Baker, Tidal Excitation of Elliptical Instability in the Martian Core: Possible Mechanism for Generating the Core Dynamo, 2008, *Journal of Geophysical Research*, 113, E06003, Doi:10.1029/2007JE002982

Behnam Seyed-Mahmoud, John Heikoop and Refah Seyed-Mahmoud, Inertial modes of a compressible fluid core model, 2007, *Geophysical and Astrophysical Fluid Dynamics*, 101, 489–505

Behnam Seyed-Mahmoud, Michael Rochester, Dynamics of rotating fluids described by scalar potentials, 2006, *Physics of the Earth and Planetary Interiors*, 156, 143–151.

Behnam Seyed-Mahmoud, Keith Aldridge, Gary Henderson, Elliptical instability in rotating ellipsoidal fluid shells: applications to the Earth's fluid core, 2004, *Physics of the Earth and Planetary Interiors*, 142, 257–282

Behnam Seyed-Mahmoud, Gary Henderson and Keith Aldridge, A numerical model for the elliptical instability of the Earth's fluid outer core, 2000, *Physics of the Earth and Planetary interior*, 117, 51-61

Keith Aldridge, Behnam Seyed-Mahmoud, Gary Henderson, William van Wijngaarden, Elliptical instability of the Earth's Fluid Core, 1997, *Physics of the Earth and Planetary interior*, 103, 365-374

G. Gumbs, G. S. Dubey, A. Salman, B. S. Mahmoud, D. Hung, Statistical and transport properties of quasiperiodic layered structures: Thue-Morse and Fibonacci, 1995, *Physical Review B*, 52, 210-219

SUPERVISION OF HIGHLY QUALIFIED PERSONNEL

Md. Kamruzzaman, January 2013 – Present, M.Sc. candidate
Project Title: The inertial modes of the Earth’s fluid core

Hossein Naseri, January 2013 – Present, M.Sc. candidate
Project Title: The Earth's wobble and nutation modes

Ali Moradi, M.Sc. candidate, January 2012 – Present, M.Sc. candidate
Project Title: Elliptical instability of the Earth's fluid core in the non-linear regime

Michel Nzikou, M.Sc., 2011-2013, M.Sc. degree
Project Title: Slichter Modes of the Earth

Christopher Rogers, Research Assistant: Third year Undergraduate Engineering Physics student (GPA 4.0) from the University of Alberta; summer 2010.

Michael DeCoste, Research Assistant: Undergrad Science Student, summer 2010, **Chinook Scholarship.**

Mian Zhang., Ph.D., 2006 - 2009: Co-supervised, Shanghai Astronomical Observatory, Shanghai, China, Mian defended his Ph.D. thesis in August, 2008 and is now faculty member at Shanghai Astronomical Observatory. He spent six months at the University of Lethbridge in 2007.

Dillon Hambrook, Research Assistant: undergraduate physics student, fall 2007- spring 2009, **NSERC Scholarship**

Mark Tipper, Research Assistant, M.Sc., Physics, January 2007 - July 2007; Mark is now an Academic Assistant (Instructor) with the Physics Department at the University of Lethbridge
Lung-Chi Wang, Research Assistant, fourth-year physics student, spring 2007 – summer 2007

John Heikoop, Research Assistant: third-year science/education student, spring 2006, summer 2006

Refah Seyed-Mahmoud, Research Assistant: third-year physics student (with Summer Career Placements (SCP) grant from the Government of Canada), summer 2006

Matthew Allen, Research Assistant: fourth-year physics student, summer 2005 - spring 2006

Rahim Kassam, Research Assistant: fourth-year computer science student, fall 2004- spring 2005

Crystal Genert, Research Assistant: fourth-year physics/education (with Summer Career Placements (SCP) grant from the Government of Canada), summer 2004

WORK IN PROGRESS

Elliptical instability in the planetary fluid cores

We are investigating the elliptical instability developed in the planetary fluid cores, as a result of the gravitational pull of nearby bodies, in the nonlinear regime using a finite element method.

Our goal is to solve the nonlinear equations of the instability. This will yield the growth rate of the instability, hence the amplitude of the motion, in the nonlinear regime. Since the objective of this study is to improve our knowledge of the dynamics of Earth's deep interior we choose the geometry as close to that of the Earth's fluid core as possible. The presence of this phenomenon in the planetary and stellar systems, elliptically deformed by gravitational tides, has been suggested for several decades. If excited, the elliptical instability may energize the Earth's magnetic field, which is generated in the Earth's fluid core, and explain its quasi periodic reversal. It may also be responsible for the surprising existence of a magnetic field in Io[1] and for fluctuations in the Earth's magnetic. Arkani-Hamed and Seyed-Mahmoud et al. (2008) have proposed that the Mars' dynamo, which was responsible for the magnetic field frozen in the planet's crust, was also energized by an elliptical instability developed as a result of the gravitational pull of a giant asteroid orbiting Mars early in the planet's history. (Thesis topic for Ali Moradi, MSc candidate)

The Earth's free Wobble and Nutation

The objective of this project is to investigate the wobble/nutation modes for the most realistic model of the Earth which includes a compressible fluid outer core (OC), an elastic mantle (MT) and inner core (IC). We plan to deviate from the conventional approach to predicting these motions of the Earth by applying to the three-potential description (3PD) approach in the Earth's fluid core and using a Galerkin method to solve the relevant equations in all parts of the Earth considering the effects of second order term in the ellipticity of the equipotential surfaces. In order to avoid the difficulties with the derivatives of the material property profiles we will solve the above equations using a non-orthogonal (Clairaut) coordinate system. (Thesis topic for Hossein Naseri, MSc candidate)

Inertial modes of the Earth's fluid core

The Earth's outer core is a rotating ellipsoidal shell of compressible, stratified and self gravitating fluid. As such, in the treatment of geophysical problems a realistic model of this body needs to be considered. Historically an incompressible and homogeneous fluid (the Poincaré model) is considered in order to study the inertial modes of this body (e.g., Bryan 1889 and Poincare´ 1910). Seyed-Mahmoud and Moradi (2013) consider a compressible and stratified fluid in order to investigate the effects of the density stratification on the periods of the inertial modes of spherical and spherical shell models of the core. They show that these effects may be significant and may be different for modes of different spatial structure and frequency. They have found, to the degree they investigated, that for core models with different stability parameters the frequencies of some modes may remain the same and those of others change, or some modes may disappear, from one core model to another. We plan to use similar core models and study these modes thoroughly. Specifically, we will use analytical, computational and numerical techniques to investigate the frequencies and the special structure of these modes in realistic models. We will also investigate the possibility that there may not be a one-to-one correspondence between the inertial modes of different core models. (Thesis topic for Md. Kamruzzaman, MSc candidate)

[1] Io is the innermost of the four Galilean moons of the planet Jupiter and, with a diameter of 3,642 kilometres (2,263 mi), the fourth-largest moon in the Solar System.

CONFERENCE PROCEEDINGS

M. Zhang, B. Seyed-Mahmoud, C. L. Huang, Preliminary result of the Earth's free oscillations by Galerkin method, *Proceedings of the IAU Symposium No. 248*, 2008, International Astronomical Union, 2 pages

Arkani-Hamed J., Seyed-Mahmoud B. and Aldridge, K., 2007, Tidal Excitation of the Core Dynamo of Mars, *Proceedings of the 38th Lunar and Planetary Science Conference (Lunar and Planetary Science XXXVIII)*, 2 pages

B. Seyed-Mahmoud and Larry R. Lines, 2002, Amplitude Migration in Anisotropic Media, *Proceedings of the Canadian Society of Exploration Geophysics National Convention*, 3 pages

B. Seyed-Mahmoud and L. R. Lines, 2001, Ray Tracing and Travel Times in Anisotropic Media, *Proceedings of the Canadian Society of Exploration Geophysics National Convention*, 3 pages

CONFERENCE PRESENTATIONS

Moradi, A. and Seyed-Mahmoud, B., 2013, Numerical study of elliptical instability in a rotating tri-axial ellipsoid, American Geophysical Union (AGU) general meeting, San Francisco, USA

Seyed-Mahmoud, B. and Moradi, A., 2013, Dynamics of rotating spheroidal fluid bodies: implementation of a Clairaut coordinate system, American Geophysical Union (AGU): Meetings of the Americas, Cancun, Mexico (Oral presentation)
Seyed-Mahmoud, B. and Moradi, A., 2012, Inertial modes of a realistic Earth Model, American Geophysical Union (AGU) general meeting, San Francisco, USA

Nzikou, M. and Seyed-Mahmoud, B., 2012, the Slichter Modes of the Earth, Canadian Geophysical Union (CGU) Annual Meetings, Banff, Canada (Oral presentation)

Moradi, A. and Seyed-Mahmoud, B., 2012, Elliptical instability of the Earth's fluid core in the non-linear regime, Canadian Geophysical Union (CGU) Annual Meetings, Banff, Canada (Oral presentation)

Seyed-Mahmoud B., 2011, The Earth's normal modes: wobble/nutation revisited, American Geophysical Union (AGU) general meeting, San Francisco, USA

Seyed-Mahmoud, B., 2011, The Earth's Free Wobbles and Nutations, Canadian Geophysical Union (CGU) Annual Meetings, Banff, Canada (Oral Presentation)

Seyed-Mahmoud, B. , 2010, Normal modes of the Earth's fluid core: an experimental study using Digital Imaging Velocimetry, Canadian Geophysical Union (CGU) Annual Meetings, Ottawa, Ontario, Canada (Oral Presentation)

Seyed-Mahmoud, B. and Hambrook, D., 2009, Particle motion analyzed using Digital Imaging Velocimetry, Joint Assembly (including the American Geophysical Union, AGU, and the Canadian Geophysical Union, CGU), Toronto, Ontario, Canada (Oral Presentation)

Seyed-Mahmoud, B. and Arkani-Hamed J., 2008, Elliptical instability: A possible energy source for Mars' core dynamo, Canadian Geophysical Union, Banff, Alberta, Canada (presented by B. Seyed-Mahmoud) (Oral Presentation)

Arkani-Hamed, J., Seyed-Mahmoud, B., and Aldridge, K., 2007, Tidally Induced Core Dynamo of Mars, American Geophysical Union (AGU) Fall Meetings, San Francisco, California, USA (presented by J. Arkani-Hamed)

M. Zhang, B. Seyed-Mahmoud and C. Huang, 2007, The free oscillations of the Earth, The International Astronomical Union (IAU) Symposium 248, Shanghai, China (presented by C. Huang)

B. Seyed-Mahmoud, J. Arkani-Hamed, and K. Aldridge, 2007, Tidal Excitation of the Core Dynamo of Mars, 2007 American Geophysical Union Joint Assembly Meetings, Acapulco, Mexico (presented by B. Seyed-Mahmoud) (Oral Presentation)

B. Seyed-Mahmoud, M. Allen and J. Heikoop, 2006, Effects of fluid compressibility on the Earth's normal modes, SEDI (Study of the Earth's Deep Interior) Meetings, Prague, The Czech Republic (presented by B. Seyed-Mahmoud)

B. Seyed-Mahmoud, 2005, Fluid compressibility and the Earth's normal modes, American Geophysical Union fall meetings, San Francisco, California, USA (presented by B. Seyed-Mahmoud)

B. Seyed-Mahmoud, and M. G. Rochester, 2005, Dynamics of rotating fluids described by scalar potentials, Canadian Geophysical Union Meetings, Banff, Alberta, Canada (presented by B. Seyed-Mahmoud)

B. Seyed-Mahmoud, and M. G. Rochester, 2004, *Three-potential-description* of the Dynamics of Rotating Fluid Bodies, American Geophysical Union Joint Assembly, Montreal, Quebec, Canada (presented by B. Seyed-Mahmoud)

Behnam Seyed-Mahmoud, 2003, Galerkin formulation of the eikonal equation, IUGG2003 (General Assembly of the International Union of Geodesy and Geophysics), Sapporo, Japan (presented by B. Seyed-Mahmoud)

B. Seyed-Mahmoud and Larry R. Lines, 2002, Ray Tracing and Travel Times in Anisotropic Media, Canadian Society of Exploration Geophysics National Convention, Calgary, Alberta, Canada (presented by B. Seyed-Mahmoud)

B. Seyed-Mahmoud and L. R. Lines, 2001, Ray Tracing and Travel Times in Anisotropic media, Canadian Society of Exploration Geophysics National Convention, Calgary, Alberta, Canada (presented by B. Seyed-Mahmoud)

K. Aldridge, B. Seyed-Mahmoud and G. Henderson, 1999, Fluctuations of the paleomagnetic field: Manifestations of tidally forced elliptical instability of the Earth's fluid core? International Union of Geodesy and Geophysics, Birmingham, UK (presented by K. Aldridge)

B. Seyed-Mahmoud, K. Aldridge, G. Henderson, 1998, A numerical model for elliptical instability of the Earth's fluid core, Study of the Earth's Deep Interior (SEDI) Annual Meetings, Tours, France (presented by B. Seyed-Mahmoud)

K. Aldridge, B. Seyed-Mahmoud, 1998, Laboratory experiments on elliptical instability in a rotating fluid shell, Study of the Earth's Deep Interior (SEDI) Annual Meetings, Tours, France (presented by K. Aldridge)

Keith Aldridge, Behnam Seyed-Mahmoud, 1998, Spectral characteristics of elliptical instability in rotating ellipsoidal fluid shells: applications to the Earth's fluid core, American Geophysical Union (AGU) Spring Meetings, Boston, Massachusetts, USA(presented by K. Aldridge)

B. Seyed-Mahmoud, K. Aldridge, G. Henderson and William van Wijngaarden, 1996, Elliptical instability in the core of the Earth, American Geophysical Union (AGU) Annual Fall Meetings, San Francisco, California (presented by B. Seyed-Mahmoud)

INVITED PRESENTATIONS

The Earth’s free wobbles and nutations, 2012, Department of Physics and Astronomy, the University of Lethbridge, Lethbridge, Alberta, Canada

Elliptical instability: A possible energy source for Mars’ core dynamo, 2008, Department of Physics and Astronomy, the University of Lethbridge, Lethbridge, Alberta, Canada

Normal modes of the Earth, 2007, Department of Physics and Astronomy, the University of Lethbridge, Lethbridge, Alberta, Canada

The normal modes of rotating fluids: applications to planetary and stellar interiors, 2005, Shanghai Astronomical Observatory, Shanghai, China

Elliptical instability in rotating spheroidal fluid shells: application to the Earth’s fluid core, 2005, Shanghai Astronomical Observatory (Chinese Academy of Sciences)**,** Shanghai, China

One day lecture on “Application of a Galerkin method on the oscillatory dynamics of rotating fluids”, 2005, Geodynamics Group, Shanghai Astronomical Observatory (Chinese Academy of Sciences), Shanghai, China

Elliptical instability in the core of the Earth, 1997, Physics Department, University of Lethbridge, Lethbridge, Alberta, Canada

SCIENCE AND TECHNOLOGY

We have developed a new set of equations describing the linearized dynamics of a rotating, self gravitating, stratified, compressible, inviscid fluid body by an exact description in terms of three scalar fields which are constructed from the dilatation, and the perturbation in pressure and gravitational potential.

We have developed computational tools in computer software, using a Galerkin method, to solve the above mentioned equations in order to predict the modal frequencies and eigenfunctions of rotating fluid bodies. We have successfully implemented these techniques to compute the modal frequencies of rotating planets and stars.

We have designed and built an apparatus, simulating planetary and stellar bodies, which we use to excite the normal modes of a rotating sphere and spherical shell.

We have also designed and built a PIV (Particle Imaging Velocimetry) system with the camera and the laser module in the rotating frame of the fluid so that when at solid body rotation, there is minimum particle motion relative to the camera. The camera takes a digital video clip of a horizontal plane of the rotating fluid. The clip is transmitted to a computer where the consecutive pictures are correlated, using PIV software, and a velocity field is mapped. The PIV software was modified from the original version developed by the *Coriolis Group* in France, http://www.coriolis-legi.org/coriolis.htm, and made available free of charge.

SCIENCE TEAM MEMBERSHIP

Member of a Canadian science team from the University of Lethbridge, University of Toronto, York University and McGill University, for a concept study of the magnetic field of Mars; we proposed to build a Canadian nano-satellite to be sent to Mars in order to make measurements of the Mars' magnetic field. The project was funded by the Canadian Space Agency (CSA) for the concept study stage (see Research Grants).

COURSES TAUGHT

Physics 3840, Introduction to computational physics, University of Lethbridge

Physics 5840, (Graduate course) Introduction to computational physics, University of Lethbridge

Physics 7840, (Graduate course) Introduction to computational physics, University of Lethbridge

Physics 5900, (Graduate course) Continuum Mechanics, University of Lethbridge

Physics 5900, (Graduate course) Computational Physics: introduction to Finite Element Method in Geophysical Problems, University of Lethbridge

Physics 2980, Broadcast/Electrical Engineering, University of Lethbridge (Applied Study)

Engineering 2000, Engineering Mechanics: Statics, University of Lethbridge

Engineering 2060, Engineering Mechanics: Dynamics, University of Lethbridge

Physics 2130, Waves, Optics and Sound, University of Lethbridge

Physics 2120, Introduction to Thermodynamics, University of Lethbridge

Physics 2020, Physics and Society, University of Lethbridge

Physics 1000, Introduction to Physics I, University of Lethbridge

Laboratory sections of Physics 1000, Physics 1050, Physics 2000, Physics 2130, Physics 2900