

Pacific Institute for the Mathematical Sciences



SYMMETRY, METHODS, APPLICATIONS AND RELATED FIELDS:

CELEBRATING THE WORK OF **PROF. GEORGE W. BLUMAN**

Conference Program

May 13-16, 2014

Pacific Institute for the Mathematical Sciences Rm 2012 Earth Sciences Building (ESB) 2207 Main Mall, Vancouver

Message from the Organizing Committee

George Bluman will be retiring from UBC in July, 2014. To celebrate George's deep influence and on-going leadership in the field of symmetry methods for differential equations, as well as his impact on mathematics education, this conference brings together top researchers, among them his current and past collaborators and students.

George has been one of the main leaders for almost 50 years in the field of symmetry group methods and their application to differential equations. Some of his fundamental work includes: methods for finding group-invariant exact solutions to differential equations and boundary-value problems; the Bluman-Cole ``non-classical method" for obtaining exact solutions to PDEs; mapping nonlinear PDEs to linear PDEs; mapping variable coefficient linear PDEs to constant coefficient linear PDEs; discovery and use of nonlocal symmetries and nonlocal conservation laws as well as nonlocally related systems; methods for finding conservation laws of PDE; numerous applications of these methods to physically important problems. His work made symmetry-based methods a potent and usable tool in applications by a wide audience.

George has written several books which are highly regarded as being basic references in this field for applied mathematicians, physical scientists, and engineers. He has also played a strong role in promoting international academic exchanges, particularly with China. In addition, George has made many important contributions to mathematics education at the local, provincial and national levels throughout his career, for which he has received several awards.

The primary scientific goals of the conference are:

- to survey current developments and recent progress in symmetry group methods and their applications, especially in those areas in which George has made fundamental contributions;
- 2) to expand connections among all of these areas and stimulate new directions for future research;
- to discuss important open problems and new applications for symmetry methods in applied mathematics and physical sciences.

We look forward to 4 days of rich discussions and stimulating exchanges with George.

Sincerely,

Stephen Anco (Brock University, Canada); Philip Broadbridge (La Trobe University, Melbourne, Australia); Temuer Chaolu (Shanghai Maritime University, China) ; Alexei Cheviakov (University of Saskatchewan, Canada); Jean-François Ganghoffer (Universite de Lorraine,Nancy France) ; Peter Hydon (University of Surrey, UK); Martin Oberlack (TU Darmstadt, Germany); Roman Popovych (NAS Ukraine); Pavel Winternitz (CRM, University of Montreal, Canada) and Greg Reid (University of Western Ontario, Canada).

Getting Started

Get connected to the Internet: Select the "ubcvisitor" wireless network on your wireless device. Open up a web browser, and you will be directed to the login page.

- **Event Evaluation Survey**: Please help PIMS to improve the quality of its events and plan for the future by filling out the survey at the end of the conference. It is located at: <u>http://goo.gl/Tko4RX</u>
- All Speaker Abstracts can be found on Page 7 Page 15.

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• Directions, on-campus eateries, and a UBC map can be found on Page 16 – Page 17.

Tuesday May 13th, 2014: ESB Room 2012

8:30am - 9:15am	Arrival and Registration (ESB Atrium) & light refreshments (outside conference room)	
9:15am- 9:30am	Opening Remarks	
9:30am- 10:30am	George Bluman : Career Highlights in Working in the Field of Symmetries/DEs	
10:30am- 10:45am	Coffee Break (ESB 2012 lobby)	
10:45am- 11:30am	Philip Broadbridge: Applications of Nonclassical Symmetry Reductions of Nonlinear Reaction-Diffusion	
	Equations	
11:30am- 12:15pm	Brian Cantwell: Coupling Between Fuel Mass Transfer and Free-Stream Mass Flux in Boundary Layer	
	Combustion in a Circular Cross-Section Channel	
12:15pm- 2:00pm	Lunch (Self Catered: See attached list for campus dining options)	
2:00pm- 2:45pm	Greg Reid: Approximate Symmetry Analysis of Differential Equations	
2:45pm- 3:30pm:	Temuer Chaolu: Characteristic Set Algorithm for PDE Symmetry Calculation, Classification, Decision and	
	Extension	
3:30pm- 3:45 pm	Coffee Break (ESB 2012 lobby)	
3:45pm- 4:30pm:	Roman Cherniha: Symmetries of Boundary Value Problems: Definitions, Algorithms and Applications to	
	Physically Motivated Problems	
4:30pm-5:15pm	Mark Fels: Equations of Lie Type and Applications to Solving Differential Equations	
**Speaker abstracts can be found on page 7-15		

Wednesday May 14th, 2014: ESB Room 2012

8:30am - 9:00am	Light refreshments (outside conference room)
9:00am- 9:45am	Peter Olver : A Historical Overview of Symmetry Methods for Differential Equations: From Lie to Noether to
	Birkhoff to Ovsiannikov to Bluman and Beyond
9:45am -10:30am	Jean-François Ganghoffer : Symmetry Methods in Continuum Mechanics of Materials
10:30am- 10:45am	Coffee Break (ESB 2012 lobby)
10:45am- 11:30am	Martin Oberlack : Statistical Symmetries of the Infinite-Dimensional Correlation System of Turbulence,
	New Invariant Solutions and its Validation Using Large-Scale Turbulence Simulations
11:30am- 12:15pm	Zhenya Yan: Matter Waves of Some Generalized Gross-Pitaevskii Equations with
	Varying Potentials and Nonlinearities
12:15pm- 12:20pm	Remarks about Dinner
12:20pm-2:00pm	Lunch (Self Catered: See attached list for campus dining options)
2:00pm- 2:45pm	Juha Pohjanpelto : Symmetries, Conservation Laws, and Variational Principles for Differential Equations
2:45pm- 3:30pm:	Abdul H. Kara: Symmetry Structures of ASD Manifolds
3: 30pm- 3:45 pm	Coffee Break (ESB 2012 lobby)
3:45pm- 4:30pm:	S. Roy Choudhury: Building Integrable NLPDE Hierarchies with Temporally and Spatially Varying
	Coefficients
4:30pm-5:15pm	Carl Wulfman (Prof Emeritus): Conservation of energy and special conformal transformations of
	Minkowski space time.
6:30рт	Conference Dinner - Forage Restaurant (See page 17 for directions)

Thursday May 15th, 2014: ESB Room 2012

8:30am- 9:00am	Light refreshments (outside conference room)	
9:00am- 9:45am	Stephen Anco: Conservation laws and their connections (old and new) to symmetries	
9:45am -10:30am	Alexei Cheviakov: Nonlocally Related PDE Systems and Applications: History, Recent	
	Developments, and Open Problems	
10:30am- 10:45am	Coffee Break (ESB 2012 lobby)	
10:45am- 11:30am	Peter Hydon: Conservation Laws: from Differential to Difference	
11:30am- 12:15pm	pm Vladimir Dorodnitsyn : Symmetries and First Integrals for Difference Equations Which Do Not	
	Possess a Variational Formulation	
12:15pm- 2:00pm	Lunch (Self Catered: See attached list for campus dining options)	
2:00pm- 2:45pm	Alexander Bihlo : Conservative Parameterization Schemes - CANCELLED	
2:45pm- 3:30pm:	Guowu Meng : Planetary Motions and Lorentz Transformations	
3:30pm- 3:45 pm	Coffee Break (ESB 2012 lobby)	
3:45pm- 4:30pm:	Changzheng Qu : Symplectic Invariants for Curves and Integrable Systems in Centro-Equiaffine and	
	Similarity Symplectic Geometries	
4:30pm-4:50pm	Xuan Liu: Algorithms for Finding the Lie Superalgebra Structure of Regular Super-Differential	
	Equations	
4:55pm-5:15pm	Dmitry Pshenitsin: Conservation Laws of Magnetohydrodynamic Equations and Their	
	Transformational Properties	

Friday May 16th, 2014: ESB Room 2012

8:30am-9:00am	Light refreshments (outside conference room)
9:00am- 9:45am	Tiecheng Xia: The Hamiltonian Structure and Algebro-geometric Solution of a
	1 + 1-Dimensional Coupled Equations
9:45am -10:30am	Lin Luo: Quasi-periodicWaves of the Supersymmetric Modified KDV Equation
10:30am- 10:45am	Coffee Break (ESB 2012 lobby)
10:45am- 11:30am	Sarah Post: Classification of Superintegrable Systems and Algebra Contractions
11:30am- 12:15pm	Thomas Wolf: A Group Foliation Method for Finding Exact Solutions to Nonlinear PDEs
12:15pm- 2:00pm	Lunch (Self Catered: See attached list for campus dining options)
2:00pm- 2:45pm	Michael Ward: An Asymptotic Analysis of the Persistence Threshold for the Diffusive Logistic Model
	in Spatial Environments with Localized Patches
2:45pm- 3:30pm:	Akira Yoshioka: Star Product and its Application
3:30pm- 3:45 pm	Coffee Break (ESB 2012 lobby)
3:45pm- 4:05pm:	Abdus Sattar Mia: Conservation Laws of the Incompressible Two-Fluid System
4:10pm-4:30pm	Elsa Dos Santos Cardoso-Bihlo: Invariant Parameterization Schemes CANCELLED
4:30pm-4:45pm	Closing Remarks

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Speaker Abstracts

**Alphabetical by surname

Stephen Anco: Brock University, Canada

Conservation laws and their connections (old and new) to symmetries

I will first review a standard method for finding the conservation laws of any given PDE system and emphasize its adjoint relationship to Lie's method for finding the symmetries of the same PDE system. I will then discuss several interesting connections between symmetries and conservation laws, going beyond Noether's theorem: Ibragimov's formula, Lagrange anchors, and a variational dilation identity.

CANCELLED: Alexander Bihlo: Memorial University of Newfoundland, Canada

Conservative Parameterization Schemes

A major problem in meteorology and geophysics is the wide variety of scales on which physical processes take place. Due to the prohibitive amount of computations that would be required to resolve all physically active scales explicitly, it is generally necessary to describe small scale effects in numerical models conceptually. The problem of modelling the effects of these so-called subgridscale processes on the resolved grid-scale part of numerical model is referred to as parameterization. In this talk we will introduce different methods for constructing conservative parameterization schemes, i.e. closure models that preserve conservation laws of differential equations. The problem of finding conservative parameterization schemes is critical as even if subgrid-scale effects cannot be resolved explicitly in a numerical model of the Earth system, the closed model should still respect the fundamental conservation laws of the original governing differential equations. We will present examples for conservative parameterization schemes for the shallow-water equations and the incompressible Euler equations in a rotating reference frame.

George Bluman: University of British Columbia, Canada

Career Highlights in Working in the Field of Symmetries/DEs

In this talk, the following will be discussed:

- A short overview of problems in Symmetries/DEs
- Highlights of work with superb collaborators
- Chronology of progress and major influences in our work
- Some Postdoctoral Fellows and young researchers mentored at UBC

Philip Broadbridge: La Trobe University, Australia

Applications of Nonclassical Symmetry Reductions of Nonlinear Reaction- Diffusion Equations

The 1969 paper by Bluman and Cole stimulated a lot of research on invariant solutions that could not be recovered from Lies classical method. Only a special class of reaction-diffusion equations has full nonclassical reductions to solutions that are not invariant under classical symmetries. However some of those equations have important applications. For 1+1 dimensional linear diffusion with a nonlinear reaction, only equations such as the Fitzhugh-Nagumo equation, and the Huxley equation, with cubic source terms, have strictly nonclassical invariant solutions. Under the assumptions set down by Fisher in 1930, the advance of a new advantageous gene through a diploid population is governed not by Fishers equation but by Huxley's equation. For nonlinear reaction-diffusion equations in two spatial dimensions, there is a single restriction relating nonlinear diffusivity to nonlinear reaction that always allows nonclassical

reduction to Laplace's equation. This allows us to construct a large class of unsteady solutions to a reaction-diffusion equation with Arrhenius reaction term that follows from the Gibbs non-analytic temperature-dependent probability distribution.

Brian J. Cantwell: Stanford University, USA

Coupling Between Fuel Mass Transfer and Free-Stream Mass Flux in Boundary Layer Combustion in a Circular Cross-Section Channel

Boundary layer combustion is the primary mechanism of hot gas generation in hybrid rocket propulsion. The idea of a hybrid rocket is to store the oxidizer as a liquid and the fuel as a solid, producing a design that is less susceptible to chemical explosion than conventional solid and bipropellant liquid designs. The fuel is contained within the rocket combustion chamber in the form of a cylinder, with a circular channel called a port hollowed out along its axis. Upon ignition, a diffusion flame forms over the fuel surface along the length of the port. Combustion is sustained by heat transfer from the flame to the solid fuel causing continuous fuel vaporization until the oxidizer flow is turned off. The theory of boundary layer combustion developed in the 1960's shows that the fuel mass transfer rate is proportional to the free-stream mass flux. The mass flow rate increases with axial distance leading to coupling between the local fuel regression rate and the local mass flux. For proper design, accurate expressions are needed for both the time dependent oxidizer-to-fuel ratio at the end of the port, and the time at which all the fuel is consumed. The coupled, nonlinear first order partial differential equations that govern the mass flow admit a three-dimensional Lie algebra that can be used to determine a similarity solution of the problem. Comparison between the similarity solution and experimental data from recent motor firings shows a remarkable level of agreement.

Temuer Chaolu: Shanghai Maritime University, China

Characteristic Set Algorithm for PDE Symmetry Calculation, Classification, Decision and Extension

In this talk, we give a review on characteristic set algorithm for PDE symmetry calculation, classification, decision and extension done in recent years by author. A key step of solving these problems is to analysis and solves so called determining system. The essential idea of our research for the purposes is in the following. First we turn the problems of PDE symmetry calculation, classification, decision and extension equivalently into ones of dealing with the zero point set of differential polynomial system (d.p.s). The target of the idea is that we focus our attention on the analysis of the zero point set and algebra properties of the d.p.s corresponding to determining equations of the symmetry. Then we use the characteristic set theory and algorithm fundamental tool in differential algebra on the transferred problems and solve original problems. Doing so, we can get an alternative ways to discuss these problems from differential algebra point and get automatic algorithm to obtain concrete symmetry and decision of (non-classical) symmetry existence for a PDE. Meantime, the algorithm can give symmetry classification and symmetry extension of a PDE with arbitrary parameters. The main research works are presented in the following articles.

[1] Temuer Chaolu & George Bluman. An algorithmic method for showing existence of nontrivial non-classical symmetries of partial differential equations without solving determining equations. J. Math. Anal. Appl. **411** (2014) 281{296.

[2] Temuer Chaolu & Pang Jing. *An algorithm for the complete symmetry classification of differential equations based on Wu's method.* J. Eng. Math. **66** (2010) 181{199.

[3] Temuer Chaolu & Bai Yu Shan. *A new algorithmic theory for determining and classifying classical and non-classical symmetries of partial differential equations* (in Chinese). Sci. Sin. Math. **40**(4) (2010) 331{348.

[4] Temuer Chaolu, Eerdun Buhe & Xia Tiecheng. *Non-classical symmetry of the wave equation with source term*. Chinese Journal of Contemporary Mathematics **33**(2) (2012) 157{166.

[5] George Bluman & Temuer Chaolu. New conservation laws obtained directly from symmetry action on a known conservation law. J.
 Math. Anal. Appl. 322 (2006) 233{250.

[6] George Bluman & Temuer Chaolu. *Local and nonlocal symmetries for nonlinear telegraph equation.* J. Math. Phys. **46** (2005) 023505.

[7] George Bluman & Temuer Chaolu. *Conservation laws for nonlinear telegraph equations*. J. Math. Anal. Appl. **310** (2005) 459{476.
[8] George Bluman & Temuer Chaolu. *Comparing symmetries and conservation laws of nonlinear telegraph equations*. J. Math. Phys. **46** (2005) 073513.

Roman Cherniha: University of Nottingham, UK

Symmetries of Boundary Value Problems: Definitions, Algorithms and Applications to Physically Motivated Problems One may note that the symmetry-based methods were not widely used for solving BVPs. To the best of our knowledge, the first rigorous definition of Lies invariance for BVPs was formulated by George Bluman in early 1970s. In our recent papers [1, 2], a new definition of Lie's invariance of BVP with a wide range of boundary conditions (including those at infinity and moving surfaces) was formulated. Moreover, an algorithm of the group classification for the given class of BVPs was worked out. The definition and algorithm were applied to some classes of nonlinear two-dimensional and multidimensional BVPs of Stefan type with the aim to show their efficiency. In particular, the group classification problem for these classes of BVPs was solved, reductions to BVPs of lower dimensionality were constructed and examples of exact solutions(with physical meaning) were found. Very recently, a definition of conditional invariance for boundary-value problems (BVPs) was proposed and applied to some nonlinear BVPs including those with the governing (1+2)dimensional heat equation. Its relation with the definitions, which were earlier worked out for Lie's invariance, is also shown. The talk will be based on the papers [1, 2] and some unpublished results obtained recently in collaboration with John R. King. This research was supported by a Marie Curie International Incoming Fellowship within the 7th European Community Framework Programme. <u>References</u>:

[1] R. Cherniha & S. Kovalenko, *Lie Symmetries of Nonlinear Boundary Value Problems*, Commun. Nonlinear. Sci. Numer. Simulat. 17 (2012) 71{84.

[2] R. Cherniha & S. Kovalenko, *Lie Symmetries and Reductions of Multi- Dimensional Boundary Value Problems of the Stefan Type*, J. Phys. A: Math. Theor. **44** (2011) 485202 (25 pp.).

Alexei Cheviakov: University of Saskatchewan, Canada

Nonlocally Related PDE Systems and Applications: History, Recent Developments, and Open Problems

The talk will begin with a historical overview of research pertaining to nonlocally related PDE systems, nonlocal symmetries, nonlocal conservation laws, the resulting exact solutions of partial differential equations (PDEs), and related methods. Classical and recent results in the area will be discussed and summarized. The talk will be concluded with an overview of open problems.

S. Roy Choudhury: University of Central Florida, USA

Building Integrable NLPDE Hierarchies with Temporally and Spatially Varying Coefficients

In the present talk, we present two techniques, based on generalized Lax pairs and similarity transformation methods, to derive generalizations of various integrable (in the Lax sense) NLPDE hierarchies. As illustrative examples, we consider a generalized NLS equation, as well as a very recent non-local and PT-symmetric NLS equation. We demonstrate that the techniques yield integrable equations with both time- AND space-dependent coefficients, and are thus more general than cases with only temporally varying

coefficients treated earlier via the Painlev'e Test and the use of Bell polynomials. The methods have been applied to generalize some well-known integrable NLPDE hierarchies, and are currently being applied to others as well. This is a joint work with Matt Russo.

Vladimir Dorodnitsyn : Keldysh Institute of Applied Mathematics, Russian Academy of Sciences

Symmetries and First Integrals for Difference Equations Which Do Not Possess a Variational Formulation

A new method to find first integrals for discrete equations is presented. It can be used for discrete equations which do not possess variational (Lagrangian or Hamiltonian) formulation. The method is based on a newly established identity which links symmetries of the underlying discrete equations, solutions of the adjoint equations and first integrals. The method was applied to an invariant discretization of a third order ODE. The set of independent first integrals allows one to find the general solution of the discrete scheme. Comparison with the direct method to find first integrals is presented.

CANCELLED: Elsa Dos Santos Cardoso-Bihlo: University of Vienna, Austria

Invariant Parameterization Schemes

Numerical weather prediction models can only operate at finite resolution. However, processes below the model resolution have an impact on the processes resolved by the model and therefore cannot be omitted in the model. The proper formulation of subgrid-scale processes in terms of resolved grid scale quantities is referred to as parameterization. The aim of this talk is to discuss a method for constructing parameterization schemes that preserve invariance properties. The method is based on group classification of differential equations. By assuming a general functional dependency of the unknown subgrid-scale in terms of the known grid-scale quantities in a system of averaged differential equations turns the original unclosed differential equations into a class of differential equations which is approachable using tools from the classical group classification. The result of this procedure yields various forms of local closure ansatzes for the unresolved subgrid scale terms leading the closed differential equations having symmetry properties that are related to the original unaveraged differential equations. This is a joint work with Roman Popovych.

Mark Fels: Utah State University, USA

Equations of Lie Type and Applications to Solving Differential Equations

In this talk I will define equations of Lie type and show how they appear in solving ordinary differential equations (ODE). In particular if the group in question is solvable this produces the well-known result on solving by quadrature an ODE with a solvable Lie group of symmetries.

Using these ideas we will examine a family of scalar partial differential equations where the solution to the Cauchy problem can be solved using equations of Lie type. Again in the case of the group being solvable, the solution to the Cauchy problem is obtained using quadratures. This leads to formulas that are analogous to the D'Alembert formula for the solution to the Cauchy problem for the wave equation.

CANCELLED: Jean-François Ganghoffer : Université de Lorraine, Nancy, France

Symmetry Methods in Continuum Mechanics of Materials

A novel and rational approach based on Lie analysis is proposed to investigate the mechanical behaviour of materials exhibiting experimental master curves. The approach relies on the idea that the mechanical response of materials is associated with hidden symmetries, which are reflected by the form of the energy functional and the dissipation potential, when considering the framework of irreversible thermodynamics. The general objective is to reveal those symmetries from measurements and to construct constitutive laws

from them. Two ways of formulating the constitutive laws from data are exposed, and the possibility of predicting new master curves and material charts is alos highlighted. The first part of the talk is devoted to the presentation of the general methodology. Afterwards, the strategy is applied to the uniaxial creep and rupture behaviour of a Chrome-Molybdene alloy (9Cr1Mo) at different temperatures and stress levels. Constitutive equations for creep and rupture master responses are identified for this alloy, and validated on experimental data. We conclude by mentioning a few scientific challenges in the field of symmetries in mechanics.

Peter Hydon: University of Surrey, UK

Conservation Laws: from Differential to Difference

Conservation laws express fundamental properties that are common to every solution of a system of equations. For PDEs, conservation laws may be found directly, by using a method developed by George Bluman and Stephen Anco. If a given system of PDEs is the Euler-Lagrange system associated with a variational problem, one can also use Noether's two theorems on variational symmetries to extract conservation laws or relations between the PDEs. This talk describes how these ideas extend to partial difference equations. Some of the basic constructions for PDEs can no longer be used. Even so, difference analogues of the direct method and Noether's theorems have been found, together with a new result that bridges the gap between Noether's two theorems (for both PDEs and difference equations). The talk concludes with a brief discussion of the reason for the close analogy between conservation law methods for differential and difference equations.

Abdul H. Kara: University of the Witwatersrand, South Africa

Symmetry Structures of ASD Manifolds

The ASD Ricci-flat metric has a form that depends on the solutions of the second heavenly equation and has signature $(+ + \square \square)$. We study the symmetries, viz., Noether and Lie symmetries, that arise from the Euler-Lagrange equations, i.e., the 'geodesic' equations, related to the metric. We explore the relationship between these and the Killing vectors admitted by the metric. As is well known, the Noether symmetries can be used to successively reduce the geodesic equations and, in fact, these symmetries allow for double reduction as each Noether symmetry corresponds to a known conservation law via Noether's theorem.

Xuan Liu : Western University, Canada

Algorithms for Finding the Lie Superalgebra Structure of Regular Super Differential Equations

Super differential equations are a non-commutative generalization of conventional differential equations, and arise naturally in some physics field theories. Exactly solving conventional differential equations is often difficult and similarly solving super differential equations maybe difficult or impossible. Lie super symmetry is a generalization of Lie symmetry to super differential equations and the infinitesimal form of the super symmetries satisfy a super symmetry defining system. I show how to find the structure (commutator table) of Lie super algebra of symmetries of sufficiently regular super differential equations without solving their super symmetry defining system. I will use two examples to show the new method which uses existing commutative Maple commands for such noncommutative calculations.

Lin Luo: Shanghai Second Polytechnic University, China

Quasi-periodicWaves of the Supersymmetric Modified KDV Equation

Based on the bilinear method and Riemann theta function, a straightforward way is shown to construct quasi-periodic wave solutions of supersymmetric equations. The resulting theory is applied to supersymmetric Modified Korteweg de Vries equation. We analyze

asymptotic properties of the solutions and give their asymptotic relations between the quasi-periodic wave solutions and the soliton solutions.

Guowu Meng: Hong Kong University of Science and Technology

Planetary Motions and Lorentz Transformations

The goal of this talk is to convey this message concerning planetary motions: The oriented elliptic orbits for the Kepler problem and its magnetized cousins are related to each other via future-preserving Lorentz transformations and scaling transformations.

Abdus Sattar Mia: University of Saskatchewan, Canada

Conservation Laws of the Incompressible Two-Fluid System

A nonlinear model has been derived by Camassa and Choi (1999) to approximate the two-dimensional Euler equations of incompressible motion of two non-mixing fluids in a channel. We derive conservation laws for the two-fluid model using the direct conservation law construction method. Eight different conservation laws are found, including the conservation of mass, total momentum, and energy. The conserved quantities for the Camassa-Choi model arecompared with those for the full incompressible Euler system. This is a joint work with Alexei Cheviakov.

Martin Oberlack: TU Darmstadt, Germany

Statistical Symmetries of the Infinite-Dimensional Correlation System of Turbulence, New Invariant Solutions and its Validation Using Large-Scale Turbulence Simulations

Textbook knowledge proclaims that Lie symmetries such as Galilean transformation lie at the heart of fluid dynamics, i.e. the Navier-Stokes equations. These important properties also carry over to the statistical description of turbulence, i.e. to the Reynolds stress transport equations and its generalization, the infinite set of multi-point correlation equations (MPCE). Interesting enough, the MPCE admit a much larger set of symmetries, in fact infinite dimensional, subsequently named statistical symmetries. Most important, theses new symmetries have important consequences for our understanding of turbulent scaling laws, in the mathematical community named group invariant solutions. The symmetries form the essential foundation to construct exact solutions to the infinite set of MPCE, which in turn are identified as classical and new turbulent scaling laws. Examples on various classical and new shear flow scaling laws including higher order correlations will be presented. Even new scaling laws have been forecasted from these symmetries and in turn validated by large-scale simulations of Navier-Stokes equations in canonical geometries. In the past, engineers and physicists working on semi-empirical turbulence modeling have implicitly recognized at least one of the statistical symmetries, as it is the basis for one of the most well-known scaling laws - the logarithmic law of the wall, which has been employed for calibrating essentially all engineering turbulence models. Hence, an obvious conclusion is to generally make engineering turbulence models consistent with as many as possible statistical symmetries employing the idea of group invariant modeling.

Peter J. Olver : University of Minnesota, USA

A historical overview of symmetry methods for differential equations: from Lie to Noether to Birkhoff to Ovsiannikov to Bluman and beyond

I will present a (somewhat biased) overview of the history of symmetry methods for differential equations, various generalizations, and applications particularly to integration, explicit solutions, and conservation laws.

Juha Pohjanpelto: Oregon State University, USA

Symmetries, Conservation Laws, and Variational Principles for Differential Equations

Noether's first theorem associates to every generalized symmetry of a variational problem a differential conservation law for the corresponding Euler- Lagrange equations. Noether's second theorem, in turn, asserts that infinite dimensional Lie symmetry pseudogroups of a variational problem involving arbitrary functions of all the independent variables correspond to differential constraints among the Euler-Lagrange equations. These two classical results suggest the following partial converse first rigorously enunciated by Takens in 1977: Suppose that a system of differential equations is invariant under a given pseudo-group of transformations and that the system admits the conservation laws or is subject to the differential identities corresponding to these symmetries. Does it then follow that the system is variational, i.e., that it can be written as the Euler-Lagrange equations of some Lagrangian function? Besides its intrinsic mathematical interest, Takens' question has far-reaching ramifications in physical field theories where symmetries and conservation laws are of primary importance in determining the form of the field equations. In this talk I will discuss my recent joint work with G. Manno and R. Vitolo on Takens' problem for non-abelian gauge theories and with Ian Anderson on Takens' problem for metric field theories, involving the infinite dimensional pseudo-groups of gauge transformations and of local diffeomorphisms, respectively.

Sarah Post: University of Hawai'i USA

Classification of Superintegrable Systems and Algebra Contractions

In this talk, I will discuss recent advances in understanding the classification of superintegrable systems and their connection to orthogonal polynomials, as inter-basis expansion coefficients as well as representations of the associated symmetry algebras. I will review the classification of 2D systems and the connection to limits within the Askey scheme of orthogonal polynomials. I will then present recent work, joint with Jonathan Kress (UNSW) on the 3D analogs and a possible extension of the Askey scheme to multivariable orthogonal polynomials.

Dmitry Pshenitsin: Brock University, Canada

Conservation Laws of Magnetohydrodynamic Equations and Their Transformational Properties

Conservation laws of incompressible flows of ideal and viscous resistive plasma are studied. Using the direct method we derive zeroand first-order conservation laws for dynamical and stationary models in cartesian (3-D flows) coordinate systems. Action of point infinitesimal symmetries on the conservation laws are given. For each reduction under consideration we get the minimal generating set of conservation laws.

Changzheng Qu: Ningbo University, China

Symplectic Invariants for Curves and Integrable Systems in Centro- Equiaffine and Similarity Symplectic Geometries

In this talk, explicit expressions of the symplectic invariants for curves in centro-equiaffine and similarity symplectic geometries are obtained. The relationships between the Euclidean symplectic invariants and the similarity symplectic invariants for curves are established. Invariant curve flows in centroequiaffine and similarity symplectic geometries are also studied. It is shown that certain intrinsic invariant curve flows in four-dimensional similarity symplectic geometry are related to the integrable Burgers and matrix Burgers equations, and the matrix KdV equations and their extension arise from intrinsic curve flows in centro-equiaffine symplectic geometry.

Greg Reid: University or Western Ontario, Canada

Approximate Symmetry Analysis of Differential Equations

Significant generalizations of symmetry such as nonclassical and potential symmetries were introduced by George Bluman. The overdetermined systems that must be analyzed for such symmetries motivated the author to develop algorithms for extracting symmetry information. One example is an effective symbolic algorithm to determine the Lie symmetry algebra structure of transformations leaving invariant algebraic systems of partial differential equations. Such algorithms depend on generalization of Gr"obner basis methods to differential systems. In many applications, however, the differential equations describing a model are only approximately known. For example they may contain approximate parameters. However direct application of such methods to models involving approximate data is unstable and usually yields uninteresting results. In particular the presence of even tiny errors means that such methods can at most detect generic symmetry endeds, rather than exceptional symmetry rich models. In this talk we discuss progress in the numerical detection of symmetry algebras of nearby symmetry rich models could be detected. Our method is to couple the Cartan-Kuranishi prolongation-projection algorithm of the geometry of PDE, with the singular value decomposition of numerical linear algebra. The Cartan-Kuranishi algorithm is a geometrical cousin of Gr"obner bases. This is joint work with Tracy Huang and Ian Lisle of the University of Canberra.

Michael Ward: University of British Columbia, Canada

An Asymptotic Analysis of the Persistence Threshold for the Diffusive Logistic Model in Spatial Environments with Localized Patches

An indefinite weight eigenvalue problem characterizing the threshold condition for extinction of a population based on the singlespecies diffusive logistic model in a spatially heterogeneous environment is analyzed in a bounded two-dimensional domain with noflux boundary conditions. In this eigenvalue problem, the spatial heterogeneity of the environment is reflected in the growth rate function, which is assumed to be concentrated in *n* small circular disks, or portions of small circular disks, that are contained inside the domain. The constant bulk or background growth rate is assumed to be spatially uniform. The disks, or patches, represent either strongly favorable or strongly unfavorable local habitats. For this class of piecewise constant bang-bang growth rate function, an asymptotic expansion for the persistence threshold _1, representing the positive principal eigenvalue for this indefinite weight eigenvalue problem, is calculated in the limit of small patch radii by using the method of matched asymptotic expansions. By analytically optimizing the coefficient of the leading-order term in the asymptotic expansion of _1, general qualitative principles regarding the effect of habitat fragmentation are derived. In certain degenerate situations, it is shown that the optimum spatial arrangement of the favorable habit is determined by a higher-order coefficient in the asymptotic expansion of the persistence threshold. (Joint work with Alan Lindsay, U. Notre Dame.)

Thomas Wolf: Brock University, Canada

A Group Foliation Method for Finding Exact Solutions to Nonlinear PDEs

In this talk a novel symmetry-group method will be outlined which has been used successfully to find exact solutions to multidimensional wave equations and heat equations with power nonlinearities. The method is based on the geometrical idea of group foliation in which the solution jet space of a given nonlinear PDE is reduced to a quotient space of orbits under the action of a onedimensional group of symmetries admitted by the PDE. Certain algebraic homogeneity features of the group-invariant equations describing the orbits are used to seek explicit solutions by a relatively simple separation ansatz. This is joint work with Stephen Anco.

Carl Wulfman (Professor Emeritus): University of the Pacific, California.

Conservation of energy and special conformal transformations of Minkowski space time

A recently uncovered line element determines geometric relations in a space time with realistic frequency shifts and cosmological properties. It's proposed physical interpretation can be verified or falsified by observation. In the space time electromagnetic fields conserve their energy and momentum in a previously unrecognized manner that is particularly relevant in an expanding universe. Aspects of this work including its relationship with subgroups of the conformal group will be discussed.

Tiecheng Xia: Shanghai University, China

The Hamiltonian Structure and Algebro-geometric Solution of a 1 + 1-Dimensional Coupled Equations

From a spectral problem, we derived new coupled soliton equations and obtained its The Hamiltonian Structure. And then a 1 + 1dimensional coupled soliton equations are decomposed into two systems of ordinary differential equations. The Abel-Jacobi coordinates are introduced to straighten the flows, from which the algebrogeometric solutions of the coupled 1 + 1-dimensional equations are obtained in terms of the Riemann theta functions. This is joint work with Pan Hongfei.

Zhenya Yan: Institute of Systems Science, Chinese Academy of Sciences, China

Matter Waves of Some Generalized Gross-Pitaevskii Equations with Varying Potentials and Nonlinearities In this report, we consider matter wave solutions and parameters analysis of one-, two-, and three-dimensional generalized Gross-Pitaevskii equations with varying potential and nonlinearities arising from Bose-Einstein condensates on the basis of the symmetry analysis and some transformations.

Akira Yoshioka: Tokyo University of Science, Japan

Star Product and its Application

Deformation quantization is to deform a commutative algebra of functions on a manifold into an associative, commutative or noncommutative, algebra, and the deformed product is called a star product. The concept of deformation quantization was proposed by mathematical physicist around 1970, and now is used as an idea to deal with noncommutative algebra in quantum physics. In this talk, we give a brief review on deformation quantization, or star product, and discuss its applications with examples.

Directions

A. ESB Building Ground Floor Plan:



B. General Travel Directions:

Airport to UBC: Easiest by taxi (25min, around \$30). If your accommodation is at Walter H Gage Towers, please give them the address: *5959 Student Union Boulevard, UBC*. By public transport, take the Canada Line (rail) to Broadway-City Hall station. From Broadway-City Hall station, cross Broadway and Cambie streets to get to the #99 UBC bus stop in front of London Drugs. Tickets (valid for the whole journey to UBC) can be purchased from the machine in the airport station. Cost: approximately \$6. Journey time: Circa more than 1 hour

UBC Map link: http://www.maps.ubc.ca/PROD/images/pdf/ubcmap.pdf

UBC Bus Loop/Gage to Earth Science Building (ESB) 2207 Main Mall: A quick 10min walk. See UBC map. Head west past the student union building, cross East Mall and get onto Main Mall. Turn left (South) on Main Mall and Earth Science Building will be on your right after a few minutes. It is a large new building, and is on Main Mall directly across from the Beatty Biodiversity Centre and prominent blue whale skeleton.

Public Transit: Feel free to search and plan your public transport rides by visiting <u>http://www.translink.ca/</u>, where directions, ticket costs and bus schedules are indicated.

Parking at UBC: http://www.parking.ubc.ca/visitor.html

C. Forage Restaurant Directions:



By Local Transit

From: UBC Bus loop, University Blvd@ East mall

To: 1300 Robson Street, Vancover

Cash Fare: \$2.75 for an adult

Take the 44 DOWNTOWN Bus

Leaving from: UBC LOOP BAY 5

Arriving at: BURRARD ST @ ROBSON ST

Walk: West up Robson until Jervis St., destination is on the left

By Taxi:

Please call Yello Cabs at 604-681-1111 and give them your departure point

By Car:

Please use Google Maps <u>here;</u> Drive time: 21- 25 minutes; Distance: 13km



Map Directory

Site or Building Name & Address	Grid
Abdul Ladha Science Student Ctr, 2055 East Mall	D4
Acadia/Fairview Commonsblock, 2707 Tennis Cres	G7 G7
Acadia Park Residence	F/H-6/7
Acadia Park Highrise, 2/25 Melta Kd	G/ H7
Allard Hall [Faculty of Law], 1822 East Mall	B4
Anthropology & Sociology Bldg, 6303 NW Marine Dr	A3
Aquatic Centre, 6121 University Blvd Aquatic Ecosystems Research Lab (AERL) 2202 Main Mall	D5 F3
Asian Centre, 1871 West Mall	B2
Auditorium (a.k.a. "Old Auditorium"), 6344 Memorial Rd	C3
Auditorium Annex Offices, 1924 West Mall Barn (davcare), 2323 Main Mall	C3 F3
3.C. Binning Studios (formerly Hut M-17), 6373 University Blvd	D3
Beaty Biodiversity Centre & Museum, 2212 Main Mall	E3/4
3elkin (Morris & Helen) Art Gallery, 1825 Main Mall Berwick Memorial Centre, 2765 Osovoos Cres	B3 G6
Bioenergy Research & Demonstration Bldg., 2337 Lower Mall	E2
Biological Sciences Bldg [Science Faculty office], 6270 University	/ BlvdD3
Biomedical Research Ctr, 2222 Health Sciences Mail	E4 D4
Bollert (Mary) Hall, 6253 NW Marine Dr	
Bookstore, 6200 University Blvd	D4
Botanical Garden Centre/Gatehouse, 6804 SW Marine Dr	H1
Botan. Gard. Greenhses/ Workshops, 6088 S. Campus RdS	South Campus
Brimacombe Building, 2355 East Mall	F4
BROCK HALL: Student Services & Welcome Centre, 1874 Ea	st Mall C4
Buchanan Building (Blocks A. B. C. D. & E) [Arts], 1866 Main Ma	04 II
Buchanan Tower, 1873 East Mall	C4
C.K. Choi Building for the Institute of Asian Research, 1855 Wes	Mall B2
Campus & Community Planning, 2210 West Mall	E3
Carey Centre, 5920 Iona Drive	B6
Carey Theological College, 1815 Wesbrook Mall	B6
CAWP (Centre for Advanced Wood Processing), 2424 Main Mall	F4
Cecil Green Park House, 6251 Cecil Green Park Rd	A3
CEME — see Civil & Mechanical Engineering Building	
Centre for Comparative Medicine, 4145 Wesbrook MallS	outh Campus
CERC (Clean Energy Research Ctr), 2360 East Mall	F4
Chan Centre for the Performing Arts, 6265 Crescent Rd	B4
Chancellor Place neighbourhood	B5
Chemical & Biological Engineering Blog, 2360 East Mail	F4 Blvd D4
Chemistry B.C,D & E Blocks, 2036 Main Mall	D3
Child Care Services Administration Bldg, 2881 Acadia Rd	H7
Child Care Services Bldgs, Osoyoos Cresc and Revelstoke Crt CIRS — see Centre for Interactive Research on Sustainability	H/
Civil & Mechanical Engineering Bldg (CEME), 6250 Applied Science	nce Lane E4
Civil & Mechanical Eng. Labs ("Rusty Hut"), 2275 East Mall	E4
Coal & Mineral Processing Lab, 2332 West Mall	Mall D2
Copp (D.H.) Building, 2146 Health Sciences Mall	D5
Cunningham (George) Building [Pharmaceutical Sc.], 2146 East	Mall E4
Javid Lam Learning Centre, 6326 Agricultural Rd	
Donald Rix Building, 2389 Health Sciences Mall	
Doug Mitchell Thunderbird Sports Centre, 6066 Thunderbird Blvc	lG5
Dorothy Somerset Studios (formerly Hut M-18), 6361 University E Earth Sciences Building (ESB) under construction, 2207 Main M	3lvdD3
Earth & Ocean Sciences (EOS) - Main and South, 6339 Stores R	tdE3
Earthquake Engineering Research Facility (EERF), 2235 East Ma	all E4
Engineering High Head Room Lab, 2225 East Mall	E4
Environmental Services Facility, 6025 Nurseries Rd	Couth Campus
airview Crescent Residence, 2600-2804 Fairview Cres	F6
Fire Department, 2992 Wesbrook Mall	H6
-irst Nations Longnouse, 1985 West Mail	
Food, Nutrition and Health Bldg, 2205 East Mall	E4
Forest Sciences Centre [Faculty of Forestry], 2424 Main Mall	F4
-orward (Frank) Building, 6350 Stores Rd	E Mall H4
PInnovations (Pulp & Paper Division), 3800 Wesbrook MallS	South Campus
raser Hall (public rental housing), 2550 Wesbrook Mall	G6
-raternity Village, 2880 Wesbrook Mall	Hb B3
Friedman Bldg, 2177 Wesbrook Mall	
Gage Residence, 5959 Student Union Blvd	C5
seneral Services Administration Bldg (GSAB), 2075 Wesbrook M Seography Building, 1984 West Mall	allD5
Gerald McGavin Building, 2386 East Mall	
Graduate Student Centre — see Thea Koerner House	
Green College, 6201 Cecil Green Park Rd	
Greenwood Commons (public rental housing). 2660 Weshrook M	е UIH1 IallG6
ampton Place neighbourhood	H/J-6/7
Hawthorn Place neighbourhood	G/H3
iteo builaing, 2045 East Mall Tennings Building, 6224 Agricultural Rd .	D4
lenry Angus Building [Sauder School of Business], 2053 Main M	allD3

Site or Building Name & Address	Grid
Hillel House - The Diamond Foundation Centre for Jewish Cam	pus Life,
6145 Student Union Blvd	C4
Horticulture Building/Greenhouse, 6394 Stores Rd	E2/3
Hugh Dempster Pavilion, 6245 Agronomy Rd	F4
CICS/CS (Institute for Computing, Information	
& Cognitive Systems/Computer Science), 2366 Main Mall	F4
nstructional Resources Centre (IRC), 2194 Health Sciences Ma	all E5
nternational House, 1783 West Mall	B2
n-Vessel Composting Facility, 6035 Nurseries Road	South Campus
rving K. Barber Learning Centre, 1961 East Mall	C4
Jack Bell Building for the School of Social Work, 2080 West Ma	llD3
John Owen Pavilion & Allan McGavin Sports Medicine Centre,	
3055 Westrook Mall	H5
Naiser (Fred) Building [Faculty of Applied Science], 2332 Main I	VialiE3
(de Club 2955 Acadia Dd	D3
(lingk (Loopard S.) Plda, 6356 Agricultural Pd	G/
Koerner (Walter C.) Library 1958 Main Mall	
andscane Architecture Anney, 2371 Main Mall	
asserre (Frederic) Building, 6333 Memorial Rd	
aw Faculty of - see Allard Hall	
eon and Thea Koerner University Centre, 6331 Crescent Rd	B3
Life Sciences Centre, 2350 Health Sciences Mall	F5
Liu Institute for Global Issues, 6476 NW Marine Dr	B2
Lower Mall Header House, 2269 Lower Mall	E2
Lower Mall Research Station, 2259 Lower Mall	E2
Macdonald (J.B.) Building [Dentistry], 2199 Wesbrook Mall	E5
MacLeod (Hector) Building, 2356 Main Mall	F3
MacMillan (H.R.) Bldg [Faculty of Land & Food Systems], 2357	Main Mall F3
Marine Drive Residence (Front Desk in Bidg #3), 2205 Lower M	allE2
Material Recovery Facility, 6055 Nurseries Ro	South Campus
Mathematics Annex, 1900 Mathematics Rd	
Medical Sciences Block C 2176 Health Sc Mall	
MEA Studios (formerly B.C. Binning MEA Studios) 6363 Store	s Rd F3
Michael Smith Laboratories 2185 East Mall	D4
Museum of Anthropology (MOA), 6393 NW Marine Dr	
Music Building, 6361 Memorial Rd	B/C3
Networks of Ctrs of Excellence (NCE), 2125 East Mall	D4
Nitobe Memorial Garden, 1895 Lower Mall	B/C2
Nobel Biocare Oral Heath Centre (David Strangway Bldg),	
2151 Wesbrook Mall	E5
Norman MacKenzie House, 6565 NW Marine Dr	B2
NRC Institute for Fuel Cell Innovation, 4250 Wesbrook Mall	South Campus
Uld Administration Building, 6328 Memorial Rd	
Old Auditorium — See Auditorium	C 2
Old Barn Community Centre, 0000 Thunderbird Biva	
Orchard House, 2336 West Mall	
Osborne (Robert F) Centre/Gvm 6108 Thunderbird Blvd	
Panhellenic House, 2770 Wesbrook Mall	
Peter Wall Institute for Advanced Studies, 6331 Crescent Rd	B3
Place Vanier Residence, 1935 Lower Mall	C/D2
Plant Ops Nursery/Greenhouses, 6029 Nurseries Rd	South Campus
Plant Science Field Station & Garage, 2613 West Mall	H2

	Point Grey Apartments, 2875 Osoyoos Cresc	H6
	Police (RCMP) & Fire Department, 2990/2992 Wesbrook Mall	H6
	Ponderosa Centre, 2071 West Mall.	D2
	Ponderosa Office Annexes: A, B, & C, 2011-2029 West Mall	C/D2
	Ponderosa Office Annexes: E to H, 2008-2074 Lower Mall	C/D2
	Power House, 2040 West Mall	D3
	Pulp and Paper Centre, 2385 East Mall	
	Ritsumeikan-UBC House 6460 Agronomy Rd	F2
	Rose Garden	B3
	Roy Barnett Recital Hall - in Music Building	
	Ruoby Pavilion 2584 East Mall	G4
	Scarfe (Neville) Building [Education] 2125 Main Mall	
	School of Population & Public Health (SPPH) 2206 East Mall	
	Simon K V Lee HKI LUBC House - Bldg #1 Marine Drive Res	idence E2
	Sing Tao Building 6388 Crescent Rd	R3
	Sonron House 2730 Acadia Rd	G7
	South Campus Warehouse, 6116 Nurseries Rd	South Campus
	Spirit Park Apartmente 2705 2725 Osovoos Cross	
	St Andrew's Hall/Residence 60/0 long Dr	
	St. John's Collogo, 2111 Lower Mall	
	St. Mark's College, 5035 Jona Dr.	
	Staning Research Centre 60/5 Nurseries Rd	South Campus
	Stores Dead Annov, 6368 Stores Dd	
	Student Decreation Ctr. 6000 Student Union Blud	L.
	Student Lipion Bldg (SLIP), 6138 Student Lipion Blvd	
	TEE3 (Tochnology Enterprice Escility 3) 6100 Agronomy Pd	
	Thes Keerner House [Eaculty of Graduate Studies] 6371 Cross	ont Dd 83
	Theatro Film Draduction Pldg. 6259 University Plvd	
	Theaderbird Residence, 6335 Thunderbird Cross	
	Thunderbird Residence, 0000 Thunderbird Cresc	۲/۵ ۲
	Thunderbird Station, 0200 Station No.	d Sporte
	Totem Field Studios 2613 West Mall	и эронз на
	Totem Dark Desidence, 2525 West Mall	E/C2
	TPILIME 4004 Westreek Mall	South Campus
	Triumf House (TPII IME Visiter's Desidence) 5835 Thurderhird	Blvd C6
	IIBC Bookstore 6200 University Blvd	Divu
	LIBC Earm 6182 Westreak Mall	South Campus
	UPC Hashital 2211 Wesbrook Mall	
	UBC Hospital, 2211 Wespitok Wali	EU
	UBC Terrinis Centre, 0100 Thuriderbird Bivd.	
	University Contro (Loon & Thes Keerner), 6331 Crossent Ed	UUK IVIAIIGG
	University Vehice (Leon & Thea Roemer), 0351 Crescent Rd	South Campus
	University Neighbourhoods Association, 3923 Detton Ave	
	Vanasuwar Sahaal of Theology, 6000 Jong Drive	
	Walter H. Cage Desidence, 5050 Student Union Plud	B3
	War Mamarial Cumpagium 6091 University Plud	
	Warne & William White Engineering Design Ctr. 2245 East Mall	
	Weehreek Elde 6174 University Dud	E4
	Westrack Diag, 01/4 University BIV0	South Commune
	Weshreek Village sharring control	South Campus
	West Mall Among 1022 West Mall	South Campus
	West Mall Surias Cases Dide, 2175 West Mall	
	West Wall Swilly Space Blog, 2175 West Wall	
	Wood Products Laboratory, 2324 West Mall	E3
	woodward IKC, 2194 Health Sciences Mall	
_	woodward Library, 2198 Health Sciences Mall	E4/5
-		

Site or Building Name & Address

Grid



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Note:

 Local traffic only
 along Wesbrook Mall on South Campus

Map Information

Need help finding your way on campus? Call the Campus & Community Planning MapInfo Line at 604-827-5040, M-F, 8:30-4:30

Or use the online searchable colour map at www.maps.ubc.ca



Campus Dining

at the University of British Columbia

From world-class catering to casual dining, coffee shops and internationally-inspired food outlets, UBC offers a delicious assortment of food services solutions. Here is an overview of food service providers certain to deliver a satisfying campus dining experience.

UBC Food Services

www.food.ubc.ca

Serving only locally-roasted fair trade organic shade-grown coffee at all UBC Food Services non-franchise locations

Wescadia Catering

Conference and special event catering www.catering.ubc.ca

Sage Bistro at University Centre

Casual fine dining available for breakfast, lunch and special events www.sage.ubc.ca

The Point Grill at Marine Drive Residence

New upscale casual dining restaurant open for brunch, lunch, and dinner. Open M-F

Triple O's at David Lam Research Centre

Casual dining in a family-friendly environment. Open daily

Residence Dining

Totem Park and Place Vanier Cafeterias For information about group meal plans, please call 604-822-6204 or email <u>rene.atkinson@ubc.ca</u>

Pacific Spirit Place Cafeteria at the SUB

Student Union Building, 6138 Student Union Blvd Pacific Spirit Place is open weekdays for breakfast and lunch. For information about group meal plans, please call 604-822-9310 or email <u>fred.cheng@ubc.ca</u>

Bakeshop Pasta Bar Salad Bar Pizza Pizza





Proudly Brewing Starbucks Coffee

Starbucks Coffee at Student Union Building The Barn at Main Mall Starbucks Coffee at Fred Kaiser Steamies Café at the Bookstore Pond Café at Ponderosa Centre

More Great Locations...

Niche Café at Beaty Biodivesity Museum Caffé Perugia at Life Sciences Centre Café MOA at Museum of Anthropology Ike's Café at Irving K. Barber Learning Centre Tim Horton's at Forest Sciences Centre







For guests, visitors, or groups visiting the UBC Campus, the UBC Food Services gift card is the easiest way for you and your group to dine at any of our locations.

Food Outlets

at the Student Union Building (SUB)

The SUB features a variety of food outlets all under one roof and conveniently located at the heart of campus. Get a delicious bagel or muffin to go, grab a slice of pizza at Pie R Squared, pick up some freshly made sushi or sit and enjoy a juicy beef burger at Pit Pub. The SUB has something for everyone!

Concourse and Sub-Level

Blue Chip Cookies



Proudly serving organic, fair trade coffees, cappuccinos and lattés. All our cookies and fabulous baked goods are made inhouse and baked fresh daily.

Bernoulli's Bagels



Montreal-style bagels, sandwiches, and bagel melts using high-quality ingredients and freshly squeezed vegetable or citrus juice!

The Delly

Fresh sandwiches made to order. A wide selection of salads, wraps, curries, soups and pasta made daily.

The Honour Roll



Maki rolls, nigiri, sushi, donburi rice bowls and bento boxes are made fresh throughout the day. Ask about party platters and catering.

The Pit Burger Bar



Charbroiled hamburger specials, veggie burgers, hot wings, beer-battered fish & chips and more!

The Pit Pub

Satellite big-screen sports, six high-definition TV's, great drink prices, and a great atmosphere!



The Moon Noodle House



Great wonton soup, daily specials, fresh steamed veggies, combos and hot & sour soup.

The Patio BBQ



On the south side of the SUB, Monday to Friday (weather permitting) offering grilled 1/4 pound burgers, veggie burgers, smokies and drinks.

The Pendulum Restaurant



Delicious grilled sandwiches and panninis, and lots of vegetarian and vegan dishes!

Pie R Squared



Great house-made pizza slices, great prices, cold drinks. Now offering soft-serve ice cream and doughnuts.

www.catering.ubc.ca

NEED CATERING? For catered events or meals on the go, Wescadia Catering offers a multitude of menu ideas to meet a range of dietary needs. We pride ourselves on our knowledgeable, friendly staff, professional service and quality ingredients.

University Boulevard

Restaurants and Food Outlets

University Boulevard boasts a vibrant neighbourhood feel, and features dozens of places to enjoy a sit-down meal, people-watch over coffee, or grab a quick bite on the run. Visitors will feel right at home choosing from internationally-recognized franchises and unique offerings from local entrepreneurs.

The Boulevard Coffee Roasting Co.

at David Strang, 5870 University Blvd. theboulevard.ca

Mahony & Sons Public House

at David Strang, 5990 University Blvd. www.mahonyandsons.com

The Well Café

at Regent College, 5800 University Blvd.

University Village

5700 Block, University Blvd.

Blenz Coffee Shop Booster Juice Juice & Snack Bar Mio Japan Japanese Fast Food McDonald's Breakfast – Late-Night Fast Food Pearl Fever Tea House & Snack Bar Pita Pit Lunch – Late-Night Take-Out & Delivery

International Food Fair

University Marketplace, Lower Level

A-1 Vietnamese Food Pho & Noodle House Curry Point East Indian Donair Town Persian, Mediterranean, Catering Leona Mediterranean Food Lebanese



One More Sushi Japanese Dining Only U Café Deli & Diner Starbuck's Coffee Shop University Pizza Take-Out & Delivery Vera's Burger Shack Diner Village Restaurant Chinese Dining

Malaysian Cuisine Malaysian, Thai Osaka Sushi Japanese Timpo Mongolian BBQ Stir-Fry Yi Kou Xiang Chinese









Also Recommended...

Westward Ho! PublicHouse & Grill Room at the University Golf Club www.universitygolf.com/dine