对偶与锥优化研讨班

（Workshop on Duality and Conic Optimization）

为了提高我国最优化理论与应用研究水平，清华大学方述诚讲席教授组将于 2006 年 12 月 16－18 日在清华大学举办 “对偶与锥优化研讨班”。本研讨班特别邀请国内外知名学者就对偶理论及锥优化的最新发展与应用等专题进行讲授和讨论。

组织单位 清华大学数学科学系

倡导和组织人员

方述诚 教授（清华大学，North Carolina State University），孙捷 教授（清华大学，国立新加坡大学），高扬 教授（清华大学， Virginia Polytechnic Institute and State University），邢文训 教授（清华大学数学科学系），张立平 副教授 （清华大学）。

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邀请报告专题

序号	时　间	主　讲	题　　目
专题 1	12 月 16 日 9:00-10:45	孙捷	New developments in nonlinear semidefinite optimization
专题 2	12 月 16 日 11:00-12:15	陈界山	Recent developments in second-order cone complementarity problems and SOC-functions
专题 3	12 月 16 日 13:30-15:15	**赵公允**	Representing the space of linear programs as a Grassmannian
专题 4	12 月 16 日 15:30-16:45	**沈志建**	Some results on the underlying paths and local convergence behavior of IPMs for SDLCPs
专题 5	12 月 17 日 9:00-10:45	张建中	Inverse Optimization – from Discrete to Continuous Cases
专题 6	12 月 17 日 11:00-12:15	**韩德仁**	Algorithms for road pricing and tolls efficiency analysis
专题 7	12 月 17 日 13:30-16:00	高扬	Canonical Duality Theory and Its Applications in Nonconvex Analysis and Global Optimization
专题 8	12 月 17 日 16:15-17:00	Yan Gao	Canonical duality for solving nonsmooth/nonconvex optimization problems
专题 9	12 月 18 日 9:00-11:00	李端	Achieving Strong Duality in Nonlinear Integer Programming
专题 10	12 月 18 日 11:00-16:00	Chair: **吴顺义**	Penal Discussion: Duality in global optimization Members: Ruey-Lin Sheu， Wenyu Sun, Ning Ruan，Liping Zhang

注意事项：

1、 议程安排：12 月 16 日上午 9：00-9：30 为简单开幕式及照相，随后开始专题报告。
2、 本研讨班的工作用语为中文。为鼓励学术讨论，报告间的休息时间为讨论时间。
3、 研讨班免收会务费。
4、 本研讨班将对参加研讨班的北京地区以外的青年学者或研究生给以部分住宿和伙食补贴。请有意得到资助者于 2006 年 12 月 1 日前将回执（最好用 Email)发回，回执中导师的电话和 email 地址必须填写，以确保不浪费我们的预定资源。我们将于 12 月 6 日通过 email 通知获得资助的信息。
5、 其他需要解决住宿的北京地区以外成员请在回执中标明住宿的需求，于 2006 年 12 月 1 日前将回执发回，我们尽量安排校内住宿，并将于 2006 年 12 月 6 日通知预定情况。由于届时校内宾馆床位紧张，我们无法保证能定到床位。请尽早与联系人联系并保证能按期到达。
6、 北京地区参加人员请于 2006 年 12 月 10 日前用 email 向联系人报名，以便统计人数，安排工作餐。
7、 2006 年 12 月 15 日 9：00-18：00 在清华大学数学科学系（理科楼大厅）接待预约安排住宿的研讨班成员。
8、 请尽量采用电子邮件的方式同我们联系。

回执

需要资助人员填写						
姓名		性别		教师/博士生/博士后/硕士生		
所在学校		电话		电子邮箱		
导师姓名		导师联系电话				
导师电子邮箱			是否经导师同意参加研讨班			
不需要资助人员填写						
姓名		性别		教师/博士生/博士后/硕士生		
所在学校		电话		电子邮箱		
预定床位标准		A.50 元左右，B.100 元左右，C.150 元以上，D.自己安排				
是否要求单间						

报告人简介及报告内容

1、孙捷教授（Jie Sun, National University of Singapore) received a Master of Science degree in operations research from Chinese Academy of Science in 1981, a Master of Science and a Ph.D in applied mathematics from University of Washington in 1983 and 1986, respectively. He joined the Department of Industrial Engineering and Management Sciences at Northwestern University (USA) as an assistant professor in 1986. He moved to National University of Singapore in 1993 where he was a senior lecturer and is now the only full professor in the Department of Decision Sciences. Sun Jie's research interest focuses on operations research and mathematical programming. He has published more than 80 papers in internationally refereed journals and books such as Operations Research and SIAM Journal on Optimization. His research is highly original with more than 400 citations by a wide spectrum of researchers in the world. He is a member of the Mathematical Programming Society, a co-editor of Pacific Journal of Optimization, an associate editor of four international journals, and a referee for more than 20 professional magazines and organizations. He received the Outstanding University Researcher Award in 1999, among other achievements in his academic career.

报告题目: New developments in nonlinear semidefinite optimization

Abstract: The nonlinear semidefinite optimization problem has wide applications in system control, structural design, and other fields. However, much work is yet to be done to effectively solve this problem. We will introduce some new theoretical and algorithmic development in this field. In particular, we discuss two types of algorithms that appear to be promising: The smoothing Newton method and the augmented Lagrangian method. The main results include an analysis of the quadratic convergence of the smoothing Newton method and an analysis on the "near superlinear" convergence of the augmented Lagrangian method.

2、陈界山教授 （Jein-Shan Chen，National Taiwan Normal University) graduated from Department of Mathematics, National Taiwan Normal University and obtained his Ph.D. degree under supervision of Prof. Paul Tseng from University of Washington in June 2004. Right after then, he commenced an assistant professor position at his alma mater in Taiwan. He is also a fellow member of Mathematics Division, National Center for Theoretical Sciences (NCTS) at Taipei. His research interest is mainly on continuous optimization with current focus on second-order cone complementarity problem (SOCCP) and topics related to SOC-functions. He has published two papers in Mathematical Programming and finished over 20 papers since his graduation. In addition, he has organized three workshops on optimization during 2005-2006 and is the coordinator of local committee of the Annual Meeting of Taiwanese Mathematics Society (TMS) that is held at National Taiwan Normal University on December 8-10, 2006.

报 告 题 目 ： Recent developments in second-order cone complementarity problems and SOC-functions

Abstract:

The talk consists of two parts. In the first part, I will present some recent results on second-order cone complementarity problems (SOCCP). The SOCCP, a natural extension of the well-known nonlinear complementarity problem (NCP), has a variety of applications in

engineering and operations research. Like the NCP case, there are three popular approaches, merit functions approach, nonsmooth functions approach and smoothing methods, to deal with the SOCCP. I have involved very much in the merit functions approach recently, so I shall have a thorough discussion on different merit functions for the SOCCP which is the main focus for this part. Next, I will move onto the study of so-called SOC-functions in which SOC-convexity and SOC-monotonicity will be introduced. My intention is to try to describe the characterizations of SOC-convex and SOC-monotone functions. There will have some open questions proposed during the speech.

3、**赵公允**教授 (Gongyun Zhao，National University of Singapore) received his B.S. and M.S. degrees from Department of Mathematics, Xiamen University in 1982 and 1985, respectively and his Ph.D. degree in 1991 from University of Wuerzburg, Germany. He is currently an Associate Professor at Department of Mathematics, National University of Singapore. His research interests include interior point methods for linear and conic programming, stochastic programming, a little bit game theory. Recently, he studies the space of linear programs as will be introduced in this workshop.

报告题目：Representing the space of linear programs as a Grassmannian

Abstract: In this lecture, we will introduce a new perspective to study linear programming: We study the space of all linear program (LP) instances, the LP space in short, and relations between LP instances. The motivation is to seek effective methods for solving groups of LP instances. Many problems, such as optimal control, optimization with uncertainty, etc, consist of infinitely many LP instances. Existing methods like simplex method and interior point method, which can efficiently solve individual LP instances, are unable to handle these problems. The study of an integrated space of LP instances may provide new approaches to tackle this problem. We represent the space of linear programs as the space of projection matrices. Projection matrices of the same dimension and rank comprise a Grassmannian, which has rich geometric and algebraic structures. An ordinary differential equation on the space of projection matrices defines a path for each projection matrix associated with a linear programming instance and the path leads to a projection matrix associated with an optimal basis of the instance. In this way, any point (projection matrix) in the Grassmannian is connected to a stationary point of the differential equation. We will present some basic properties of the stationary points, in particular, the characteristics of eigenvalues and eigenvectors. We will show that there are only a finite number of stable points. Thus, the Grassmannian can be partitioned into a finite number of attraction regions, each associated with a stable point. The structures of the attraction regions will be important for applications which will be discussed at the end of this lecture.

4、**沈志建博士** (Chee Khan Sim, National University of Singapore) graduated from the Department of Mathematics, National University of Singapore with B.Sc., in 1993, and obtained a Ph.D. degree from the same department, in 2005. He obtained his M.Sc. degree in optimization from the University of Washington, Seattle, in 1997. Currently, he is a

research fellow in the Logistics Institute - Asia Pacific, at NUS. His research interests include conic optimization and its applications, nonsmooth optimization, and inventory management.

报告题目：Some results on the underlying paths and local convergence behavior of IPMs for SDLCPs.

Abstract: In this talk, a new way to define the underlying paths in the feasible interior region of SDLCP, will be introduced. We will give a motivation to define paths in this way, from the point of view of interior point method. Properties of the paths, in particular, the analyticity behavior of the paths near a solution of a SDLCP, will be discussed. Asymptotic analyticity behavior of these paths is important in the study of local convergence behavior of interior point algorithms.

5、张建中教授 (Jason Zhang, Chinese University of Hong Kong) received his Bachelor degree in 1962 from Shanghai Normal University, and the PhD degree in Operations Research in 1984 from the University of Texas at Austin, USA. He worked in Shanghai Normal University until 1988 as Lecturer, Associate Professor, Professor, and Head of the Mathematics Department. He was Visiting Professor in California State University (Northridge) in 1988, and the Distinguished Visiting Professor in the Dept. of Operations Research, George Washington University in 1989. In 1990 he joined City University of Hong Kong where he was Professor and Head (1996-2002) of the Mathematics Department. In 2006 he moved to the Department of System Engineering and Engineering Management, the Chinese University of Hong Kong, as a Visiting Professor. Professor Zhang started his research in optimization in 1979. In the first twenty years he mainly worked on continuous optimization, especially on successive linear programming method, quasi-Newton method, trust region method, pipe network problem, and their applications. In addition to traditional nonlinear optimization problems, he has also been working on complementarity problem, variational inequality problem, bi-level programming problem and MPEC problem. His research interest expanded to the combinatorial optimization area in recent ten years, and in particular he has been devoted to the study of various inverse optimization problems. Professor Zhang published more than 140 research papers. He now serves in editorial boards of *Optimization Methods and Software*, *Pacific Journal of Optimization*, *Operations Research Transaction*, and *Acta Mathematicae Applicatae Sinica* (Springer). Professor Zhang is a standing committee member of the Chinese Operations Research Society, and was Vice-Chairman of the Chinese Mathematical Programming Society between 1998 and 2006. He is also one of the founding members of the Pacific Optimization Group.

报告题目： Inverse Optimization – from Discrete to Continuous Cases

Abstract : In this talk we first briefly review the development of inverse optimization and explain some methodology in handling inverse combinatorial optimization problems. We then turn to inverse problems of continuous optimization. In particular we consider in this talk an inverse quadratic programming (QP) problem in which the parameters in the objective function of a given QP problem are adjusted as little as possible so that a known feasible solution becomes the optimal one. We formulate this problem as a minimization problem with a positive semidefinite cone constraint and derive its dual which is a linearly constrained

semismoothly differentiable (SC1) convex programming problem with fewer variables than the original one. We use the augmented Lagrangian method to solve the dual problem and show that the method possesses global convergence with a convergence rate proportional to $1/r$, where r is the penalty parameter in the augmented Lagrangian. The convergence analysis requires extensive tools such as the singular value decomposition of matrices, implicit function for semismooth functions, and properties of the projection operator in the symmetric-matrix space.

韩德仁教授 (Deren Han, Nanjing Normal University) is an associate professor at School of Mathematics and Computer Sciences, Nanjing Normal University. He received his B.S. and Ph.D. degrees from Department of Mathematics, Nanjing University in 1997 and 2002, respectively. His research interests include conic optimization and its applications and numerical methods for variational inequality problems and their applications, especially in transportation research.

报告题目: Algorithms for road pricing and tolls efficiency analysis

Abstract: It is well known that in a congested network, users behave selfishly and a user equilibrium is usually different from a system optimum. A common adopted way by the network managers is to levy tolls on the links of the network. To drive a user equilibrium to a system optimum, the levied tolls should equal to the marginal cost at the system optimum, depending on the demand functions, which are usually unknown. This leads to a class of variational inequality problems with partially unknown mappings. We will introduce several numerical methods for solving such problems. On the other hand, to measure ``how far'' between a user equilibrium and a system optimum, E. Koutsoupias and C.H. Papadimitriou introduced the concept ``Price of Anarchy'', i.e., the worst ratio between the system cost occurred at a user equilibrium and the optimal system cost. We will use this concept to analyze the efficiency of the tolls by deriving some bounds of the price of anarchy when the levied tolls are considered as part of the system cost. One of the important elements in a tolled system is the value of time of the users (VOT). That is, after placing tolls on links, the users select routes between their origin and destination with least travel disutility, i.e., the travel delay plus the tolls. These require us to transform the total link latency (delay) to money or transform the total tolls to time. We will also analyze the price of anarchy with heterogenous users with different VOTs and give some insight to the role played by the VOTs.

高扬教授 (David Y. Gao, Virginia Tech)

报告题目: Canonical Duality Theory and Its Applications in Nonconvex Analysis and Global Optimization.

Abstract: Duality is an inspiring, fundamental concept that underlies almost all natural phenomena. In mathematical science, global optimization, dynamical systems, modern mechanics, economics, control theory, numerical methods and scientific computation, duality principles and methods are playing more and more important roles. Duality and methods in convex systems have been well studied. However, in nonconvex systems, these well developed theory and methods

usually lead to a so-called duality gap. Many nonconvex/nonsmooth problems in global optimization are NP-hard. In nonconvex dynamical systems, traditional direct methods may produce the so-called chaotic solutions.

Canonical duality theory is a newly developed, potentially powerful methodology, which is composed mainly of a canonical dual transformation and a triality theory. The canonical dual transformation can be used to formulate perfect dual problems without a duality gap, while the triality theory reveals an interesting duality pattern in general nonconvex system and plays a fundamental role in nonlinear analysis and global optimization.

In this talk, the speaker will present a comprehensive tutorial on the canonical duality theory and its applications in nonconvex analysis and global optimization. Beginning with the most simple but fundamentally difficult quadratic programming problem, the speaker will reveal a unified structure and splendid beauty in mathematical physics. He will first show that by using the canonical dual transformation, many well-known nonconvex/nonsmooth problems in high dimensional space can be reformulated into certain smooth canonical dual problems (i.e. without duality gap) in lower dimensional space. A large class of nonlinear partial differential equations and global optimization problems, including Landau-Ginzburg, nonlinear Schrödinger, Cahn-Hillard, Duffing equations, complementarity problems, constrained nonconvex optimization, multi-person game theory, d.c. minimization, and integer/fractional programming, etc., can be assembled in a unified framework. An insightful relation between nonlinear analysis and optimization are revealed. Therefore, complete solutions to a large class of nonlinear boundary-value problems can be obtained. For those well-known problems in dynamical systems and phase transitions, the speaker will explain the reason that leads to chaos, and why the traditional direct methods can not be used along to solve nonconvex problems. He will show that the very interesting triality theory can be used to control chaotic behaviors of nonconvex systems and to identify both global minimizer and local extrema of global optimization problems. Based on this triality theory, powerful primal-dual algorithms can be developed for solving large-scale, multi-scale nonlinear problems.

Extensive applications will be illustrated by nonconvex problems in variational analysis and global optimization. Complete solutions to certain well-known difficult problems will be presented, including polynomial minimization, quadratic programming with spherical, box, and integer constraints. This talk should bring some fundamentally new insights into nonconvex analysis, global optimization, and computational science.

Yan Gao (Shanghai University of Science and Technology):
报告题目: Canonical duality for solving nonsmooth/nonconvex optimization problems
Abstract: The most difficult type of optimization problems to solve could be nonsmooth problems. Such problems normally are, or must be assumed to be non-convex. Hence a nonsmooth optimization problem may not only have multiple feasible regions and multiple locally optimal points within each region -- because some of the functions are non-smooth or even discontinuous, derivative or gradient information generally cannot be used to determine the

direction in which the function is increasing (or decreasing). Therefore, traditional methods for solving nonsmooth problems are very difficult.

In this talk, the speaker will demonstrate the potentially powerful applications of the canonical duality theory in nonsmooth global optimization. He will first review some recent advances in nonsmooth optimization. By using a typical unconstrained nonsmooth/nonconvex problem as an example, he will show that a large class of very difficult nonsmooth/nonconvex optimization problems in n-dimensional space can be converted into certain smooth canonical (i.e. either convex minimization or concave maximization) dual problems in one-dimensional space, which can be solved to obtain all extremal points. The global minimizer and local extremal conditions can be identified by the triality theory. Applications are illustrated.

Duan Li (Chinese University of Hong Kong):

报告题目: Achieving Strong Duality in Nonlinear Integer Programming

Abstract: We consider in this talk the Lagrangian dual method for solving general integer programming. Properties of Lagrangian duality are investigated by a means of perturbation analysis. In particular, necessary and sufficient conditions for a primal optimal solution to be generated by the Lagrangian relaxation are discussed, and the solution properties of Lagrangian relaxation problem are studied systematically. To overcome the duality gap between the primal problem and the dual problem, we introduce certain equivalent reformulations for the primal problem. We prove that such reformulations lead to an achievement of a strong duality.

Penal Discussion: Duality in Global Optimization

Chair: Soonyi Wu (National Cheng Kung University, Taiwan):

Members:

Ruey-Lin Sheu (National Cheng Kung University, Taiwan),

Wenyu Sun (Nanjing Normal University),

Ning Ruan (Shanghai University Science and Tech),

Liping Zhang (Tsinghua University).

In this penal discussion, each member will present particularly application of duality theory and method for solving some very interesting problems in global optimization. Topics include nonconvex integer programming, primal-dual methods, nonconvex complementarity problems, and complete solutions to a class of nonconvex minimization problems. Future developments, open problems, and cooperation will be discussed with all audients.