UNIVERSITÀ DEGLI STUDI DI MESSINA
DIPARTIMENTO DI MATEMATICA E INFORMATICA

V.le F. Stagno d'Alcontres 31
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Estratto del
Verbale del Consiglio del
Dipartimento di Matematica e Informatica
Composizione semiristretta
26 Giugno 2015

Il giorno 26 del mese di giugno dell'anno 2015 alle ore 12:00 presso la sala riunioni del Dipartimento si è riunito il Consiglio del Dipartimento di Matematica e Informatica per discutere e deliberare in merito al seguente O.d.G.:

1) Designazione membro interno e sestina di commissari concorso RUTD S.C. 13/D4 D.R. 910 del 23/4/2015;
2) Richiesta per l'a.a. 2015/2016 di congedo per anno sabbatico prof. Riccardo Fazio.

Componenti del Consiglio.

Professori Ordinari: Cammaroto Filippo, Ciancio Vincenzo, Cubiotti Paolo, Currò Carmela, Fusco Domenico, Lo Faro Giovanni, Manganaro Natale, Oliveri Francesco, Palumbo Annunziata, Restuccia Gaetana, Restuccia Liliana, Valenti Giovanna, Vitanza Carmela.
Professori Associati: Anello Giovanni, Barbera Elvira, Bonanzinga Maddalena, Carini Luisa, Crupi Marilena, De Filippis Vincenzo, De Salvo Mario, Di Bella Beatrice, Fazio Riccardo, Li Marzi Enzo Maria, Mandanici Andrea, Provetti Alessandro, Puccio Luigia, Utano Rosanna.

ASSENTI

Professori Ordinari: Ciancio Vincenzo (A.G.), Cubiotti Paolo, Fusco Domenico (A.G.), Restuccia Gaetana, Valenti Giovanna.
Professori Associati: Bonanzinga Maddalena (A.G.), Carini Luisa, De Filippis Vincenzo, De Salvo Mario, Di Bella Beatrice, Fazio Riccardo, Provetti Alessandro.

Presiede il Consiglio il prof. Francesco Oliveri, Direttore del Dipartimento. Funge da Segretario verbalizzante la prof.ssa Marilena Crupi.
Alle ore 12:05, constatata la presenza del numero legale, il Direttore inizia la discussione con con il primo punto all'O.d.G.:

OMISSIS

Si passa a discutere il punto 2) all' O.d.G.:

2) Richiesta per l'a.a. 2015/2016 di congedo per anno sabbatico prof. Riccardo Fazio.

— Dir. Amm.vo "Ris. Umane"
p.c. Dir. DMI

Universita' di Messina
Prot. 0033615 del 27/05/2015
Tit./cl. VII/11 - Arrivo
(2015-UNMECLE-0033615)

Messina, 26 Maggio 2015

Al Magnifico Rettore Prof. Pietro Navarra,

Al Direttore del Dip.to di Matematica e Informatica
Francesco Oliveri, e

p.c. Al Coor.re del CdL e del CdLM in Matematica
Prof. Giovanni Anello,

Università di Messina
Direzione Generale
27 MAG. 2015
Gestione documenti e repertori

Oggetto: istanza Anno Sabbatico

Il sottoscritto, Riccardo Fazio, docente di Analisi Numerica (Area 01 - MAT05), afferente ai CdL e CdLM in Matematica, con rif. all'Art. 17 del DPR 382/80, fa istanza affinché possa essergli concesso un anno sabbatico retribuito nel prossimo a.a. 2015-2016, per dedicarsi esclusivamente all'attività di Ricerca.
Tale ricerca è dovuta alle collaborazioni intraprese con colleghi delle seguenti istituzioni: Università di

Riccardo Fazio Research Web-Page Home Page

Preprints

Interface, Free and Moving Boundary Value Problems

- Free Boundary Value Problems for ODEs
- Free Boundary Formulation for BVPs on Infinite Intervals
- Moving Boundary Parabolic Problems
- Moving Boundary Hyperbolic Problems
- Interface Problems

Free Boundary Value Problems for ODEs

Selected List of Papers

- Similarity and Numerical Analysis for Free Boundary Value Problems
- Normal Variables Transformation Method Applied to Free Boundary Value Problems
- Numerical Transformation Methods: A Constructive Approach
- A Numerical Test for the Existence and Uniqueness of Solution of Free Boundary Problems
- A Similarity Approach to the Numerical Solution of Free Boundary Problems
- A Non-Iterative Transformation Method for Newton's Free Boundary Problem

Similarity and Numerical Analysis for Free Boundary Value Problems, **Riccardo Fazio and David J. Evans**, ***Int. J. Computer Math., 31 (1990) 215-220; 39, (1991) 249.***

studying the behaviour of that function. Within such a context the numerical test is illustrated by two examples.

A Similarity Approach to the Numerical Solution of Free Boundary Problems, Riccardo Fazio, *SIAM Rev., 40 (1998) 616-635.*

Abstract: The aim of this work is to point out that within a similarity approach some classes of free boundary value problems governed by ordinary differential equations can be transformed to initial value problems. The interest in the numerical solution of free boundary problems arises because these are always nonlinear problems. Furthermore we show that free boundary problems arise also via a similarity analysis of moving boundary hyperbolic problems and they can be obtained as approximation of boundary value problems defined on infinite intervals. Most of the theoretical content of this survey is original: it generalizes and unifies results already available in literature. As far as applications of the proposed approach are concerned, three problems of interest are considered and numerical results for each of them are reported.

A Non-Iterative Transformation Method for Newton's Free Boundary Problem, Riccardo Fazio, *Int. J. Non-Linear Mech., 59 (2014) 23–27.*

Abstract: In book II of Newton's Principia Mathematica of 1687 several applicative problems are introduced and solved. There, we can find the formulation of the first calculus of variations problem that leads to the first free boundary problem of history. The general calculus of variations problem is concerned with the optimal shape design for the motion of projectiles subject to air resistance. Here, for Newton's optimal nose cone free boundary problem, we define a non-iterative initial value method which is referred in literature as transformation method. To define this method we apply invariance properties of Newton's free boundary problem under a scaling group of point transformations. Finally, we compare our non-iterative numerical results with those available in literature and obtained via an iterative shooting method. We emphasize that our non-iterative method is faster than shooting or collocation methods and does not need any preliminary computation to test the target function as the iterative method or even provide any initial iterate. Moreover, applying Buckingham Pi-Theorem we get the functional relation between the unknown free boundary and the nose cone radius and height.

Free Boundary Formulation for BVPs on Infinite Intervals

solution. Taking into account the "partial" invariance of the mathematical model at hand with respect to a stretching group we define a non-iterative transformation method. Further, we compare the improved numerical results, obtained by the method in point, with analytical and numerical ones. Moreover, the numerical results confirm that the question of accuracy depends on the value of the free boundary. Therefore, this indicates that boundary value problems with a boundary condition at infinity should be numerically reformulated as free boundary value problems.

The Falkner-Skan Equation: Numerical Solutions within Group Invariance Theory, Riccardo Fazio, *Calcolo, 31 (1994) 115-124*

Abstract: The iterative transformation method, defined within the framework of the group invariance theory, is applied to the numerical solution of the Falkner-Skan equation with relevant boundary conditions. In this problem a boundary condition at infinity is imposed which is not suitable for a numerical use. In order to overcome this difficulty we introduce a free boundary formulation of the problem, and we define the iterative transformation method that reduces the free boundary formulation to a sequences of initial value problems. Moreover, as far as the value of the wall shear stress is concerned we propose a numerical test of convergence. The usefulness of our approach is illustrated by considering the wall shear stress for the classical Homann and Hiemenz flows. In the Homann's case we apply the proposed numerical test of convergence, and meaningful numerical results are listed. Moreover, for both cases we compare our results with those reported in literature.

A Novel Approach to the Numerical Solution of Boundary Value Problems on Infinite Intervals, Riccardo Fazio, *SIAM J. Numer. Anal., 33 (1996) 1473-1483*

Abstract: The classical numerical treatment of two-point boundary value problems on infinite intervals is based on the introduction of a truncated boundary (instead of infinity) where appropriate boundary conditions are imposed. Then, the truncated boundary allowing for a satisfactory accuracy is computed by trial. Motivated by several problems of interest in boundary layer theory, here we consider boundary value problems on infinite intervals governed by a third order ordinary differential equation. We highlight a novel approach in order to define the truncated boundary. The main result is the convergence of the solution of our formulation to the solution of the original problem as a suitable parameter goes to zero. In the proposed formulation the truncated boundary is an unknown free boundary and has to be determined as part of the solution. For the numerical solution of the free boundary formulation a non-iterative and an iterative transformation method are introduced. Furthermore, we characterize the class of free boundary value problems that can be solved non-iteratively. A

problem can be transformed into an equivalent boundary value problem governed by an ordinary differential equation and defined on an infinite interval. A free boundary formulation and a convergence theorem for this kind of transformed problems are available in [R. Fazio, A novel approach to the numerical solution of boundary value problems on infinite intervals, SIAM J. Numer. Anal. 33 (1996), pp. 1473–1483]. Depending on its scaling invariance properties, the free boundary problem is then solved numerically using either a noniterative, or an iterative method. Finally, the solution of the parabolic problem is retrieved by applying the inverse map of similarity.

Moving Boundary Parabolic Problems

Selected List of Papers

- The Iterative Transformation Method: Numerical Solution of One-Dimensional Parabolic Moving Boundary Problems
- Similarity Analysis for Moving Boundary Parabolic Problems

The Iterative Transformation Method: Numerical Solution of One-Dimensional Parabolic Moving Boundary Problems, **Riccardo Fazio,** ***Int. J. Comp. Math., 78 (2001) 213-223.***

Abstract: The main contribution of this paper is the application of the iterative transformation method to the numerical solution of the sequence of free boundary problems obtained from one-dimensional parabolic moving boundary problems via the implicit Euler's method. The combination of the two methods represents a numerical approach to the solution of those problems. Three parabolic moving boundary problems, two with explicit and one with implicit moving boundary conditions, are solved in order to test the validity of the proposed approach. As far as the moving boundary position is concerned the obtained numerical results are found to be in agreement with those available in literature.

Scaling invariance and the iterative transformation method for a class of parabolic moving boundary problems, **Riccardo Fazio,** ***Int. J. Non-Linear Mech., 50 (2013) 136-140.***

Abstract: The reduction of one-dimensional moving boundary parabolic problems to free boundary problems governed by ordinary differential equations is considered. We indicate the iterative transformation method, defined within the

to the impact a shock front propagates with a finite speed. Here our interest is to underline the influence of the dissipative term on the propagation of the shock front. In the framework of the similarity analysis we are able to reduce the moving boundary hyperbolic problem to a free boundary value problem for an ordinary differential system. It is then possible, by applying two numerical transformation methods, to solve the free boundary value problem numerically. The influence of the dissipative term is evident: the free boundary (that defines the shock front propagation) is an increasing function of the dissipative coefficient.

An Implicit Difference Scheme for a Moving Boundary Hyperbolic Problem , Riccardo Fazio and David J. Evans, *Appl. Numer. Math., 12 (1993) 485-496*

Abstract: In this paper an implicit difference scheme is defined for a moving boundary hyperbolic problem, which describes a shock front propagation in a constant state. We have reformulated the problem to a fixed boundary domain where an implicit difference scheme is proposed. As is well known, the equivalent condition for the convergence of a consistent scheme is its stability. However, the only reliable methods of stability analysis are based on linear theory. Moreover, the pertinent literature provides simple examples where the linearization of a nonlinear scheme leads to incorrect stability results. On an experimental basis a discrete perturbation stability analysis was then considered. In order to investigate the convergence of the scheme we considered a particular example where an approximate similarity solution is known. In this case, we point out the numerical convergence of the scheme. Even more important is that a possible way to assess the numerical accuracy when the similarity solution does not exist is suggested.

Similarity and Numerical Analysis of a Singular Moving Boundary Hyperbolic Problem, Riccardo Fazio, *in Progress in Industrial Mathematics at ECMI 2000 , A.M. Anile, V. Capasso e A. Greco ed., Springer, Berlin, pp. 339-344, 2002.*

Abstract: In [SIAM Rev., 40 (1998) 616--635], we emphasized the relevance of a combination of similarity and numerical analysis for the numerical solution of moving boundary hyperbolic problems. Here we report on results obtained for one problem of the above class that is singular at the moving boundary.

Interface Problems

Selected List of Papers

A Lagrangian Central Schemes and Second Order Boundary Conditions for 1D Interface and Piston Problems , **Riccardo Fazio and Giovanni Russo,** ***Commun. Comput. Phys., 8 (2010) 797-822.***

Abstract: We study high-resolution Lagrangian central schemes for the one-dimensional system of conservation laws describing the evolution of two gases in slab geometry separated by an interface. By using Lagrangian coordinates, the interface is transformed to a fixed coordinate in the computational domain and, as a consequence, the movement of the interface is obtained as a byproduct of the numerical solution. The main contribution is the derivation of a special equation of state to be imposed at the interface in order to avoid non-physical oscillations. Suitable boundary conditions at the piston that guarantee second order convergence are described. We compare the solution of the piston problem to other results available in the literature and to a reference solution obtained in the adiabatic approximation. A shock-interface interaction problem is also treated. The results on these tests are in good agreement with those obtained by other methods.

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