Międzynarodowa Środowiskowa Szkoła Doktorska
przy Centrum Studiów Polarnych
w Uniwersytecie Śląskim w Katowicach

ul. Będzińska 60
41-200 Sosnowiec
tel. +48 32 368 93 80
polarknow@us.edu.pl
www.mssd.us.edu.pl

Reference No: IEDS/2020/IM PAN/01

Title of PhD project: Mathematical analysis of hydrodynamical models

Leading unit: International Environmental Doctoral School associated with the Centre for Polar Studies at the University of Silesia in Katowice (IEDS)

Mode of study: full-time

Degree to be obtained: PhD in the field of natural sciences, in discipline: mathematics

Duration: 4 years (8 semesters), from October 2020

Language: English

Scholarship: approx. 2370 PLN monthly (1-2nd year); approx. 3650 PLN monthly (3-4th year);

Requirements and regulations: www.mssd.us.edu.pl/kandydat-mssd/

Registration online: www.irk.us.edu.pl

Conditions of recruitment:
I STAGE: Knowledge test in the field of discipline. The test is scored on points: from 0 to 10 points.
A positive result of the test is that the candidate gets a minimum of 7 points. Absence on the test disqualifies the candidate from the entire qualification procedure.

II STAGE: a) the final result of the candidate's completion of higher education (maximum 6 points, diploma grading ratio: 6.0 (excellent) - 6 points, 5.0 - 5 points, 4.5 - 4 points, 4.0 - 3 points. 3.5 - 2 points, 3.0 - 1 point), b) for candidates (students) referred to in art. 186 para. 2 of the Act - a certificate of average grade from at least three years of uniform Master's studies, rounded to one decimal place, according to the conversion factor: 6.0 (excellent) - 6 points; 5.0 - 5 points; 4.5 - 4 points; 4.0 - 3 points; 3.5 - 2 points; 3.0 - 1 point).

III STAGE: Interview for assessing: the candidate's intellectual level, knowledge of English, substantive level of the doctoral dissertation project, motivations and predispositions for scientific work, previous scientific achievements of the candidate (maximum 15 points).

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Requirements:

1. Completed Msc in Mathematics (master's degree) or a related subject (Physics or in Computer Sciences). Knowledge of the subject in frame of analysis of partial differential equations.

2. Knowledge of issues: weak solutions, nonlinear partial differential equations, Sobolev spaces, functional analysis, nonlinear equations, fluid mechanics, collective behavior.

3. Knowledge of English enabling communication, reading, writing scientific works and cooperation in international community.

Tasks description:

1. Analysis of hydrodynamic systems of partial differential equations in terms of existence of (weak, measure) solutions, their regularity, behavior for large times, analysis when certain parameters converge to zero or infinity;

2. Processing and analysis of available literature and the latest available publications on the subject of the project.

3. Conducting research in cooperation with foreign teams. Depending on the available funding - study trips, short internships in foreign units.

4. Preparation of scientific articles and conference presentations.

5. Regular reporting of work progress;

6. Assistance in daily scientific and didactic tasks of the unit, including participation in seminars and workshops of the Institute of Mathematics of the Polish Academy of Sciences and the IMPAS and of Department of Differential Equations.

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Abstract

Within the project we will provide the mathematical analysis of nonlinear Partial Differential Equations (PDEs) and their solutions. In particular, we will concentrate on problems related to fluid mechanics, collective behaviour, interaction of objects/particles with fluid, phenomena observed in sciences, technology or nature. Such analysis will give better understanding of some complex behaviours in considered models (systems of equations). The main goal of the project is to show well-posedness of the problem together with qualitative properties of solutions.

Therefore we will try to answer some of the following questions: Are the considered systems possess solutions (strong, weak, measure-valued)? Are they global in time, unique or regular? What is their behaviour for large times? How the whole systems can change when some parameters converge to zero or infinity.

Many phenomena in nature, technology, sociology are described by models seeing it as a flow. However, there is a wide class of phenomena for which the basic Navier-Stokes system is not enough to describe more complex processes. Therefore, there is a need to construct and analyse models that take full account of their character. Here, for example: the Navier-Stokes-Smoluchowsky type systems, generalized Navier-Stokes-Vlasov system, generalized Euler systems can be used.
In particular, in the comprehensive description of many phenomena the challenge is to take into account: collective behaviour and swarming of objects, microstructure associate with particles or objects interaction with fluid which are immersed in, non-Newtonian rheology of the fluid, changes of the shape and volume of the domain, heat effects, different scales of certain parameters which matters in the system are dominant or negligible. The above mentioned phenomena are a source of nonlocal effects, nonlinearities in the system, dependence on domain changes, and may change the character of the system respectively.

The implementation of the project will require the use of advanced methods of the theory of partial differential equation and functional analysis, which the PhD student will learn during the studies. This project can be accomplished in cooperation with scientists from the University of Oxford, the Czech Academy of Sciences in Prague and University College London.

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Other information:

1. The supervisor will be dr hab. Aneta Wróblewska-Kamińska, e-mail: **awrob@impan.pl**, Institute of Mathematics Polish Academy of Sciences.
2. Contact to the Secretary of the IEDS Admission Committee: tel. +48 32 368 93 80, **polarknow@us.edu.pl, www.mssd.us.edu.pl**