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Qualification

- **2007 - 2011: PhD Thesis in Applied Mathematics**
- Subject: Influence of confinement on the spatio-temporal development of wake flows
- University of Nice - Sophia Antipolis (France)

Employment

- **01/2016**: Assistant Professor at Bilkent University (Turkey)
- **10/2013-01/2017**: Research Fellow at Imperial College London (United Kingdom)
- **09/2012-08/2013**: Research Associate at Royal Institute of Technology, KTH (Stockholm, Sweden)
- **01/2012-08/2012**: Research Associate at Imperial College London (United Kingdom)
- **09/2011-12/2011**: Postdoctoral researcher at University of Nice - Sophia Antipolis (France)

Grants

- **2021-ongoing**: TUBITAK 2507 - Bilateral cooperation programs: TUBITAK - DFG (Germany), *Distribution of Particles in a Droplet and Positioning on the Surface During Evaporation.*
- **2020-ongoing**: TUBITAK 2509 - Bilateral cooperation programs: TUBITAK - CNR (Italy), *Self-assembly of complex shaped active particles in controlled optical potentials.*
- **2019-ongoing**: European Training Network, *Active Matter: From Fundamental Science to Technological Applications*
- **2018-ongoing**: TUBITAK 3501, Career Development Program (CAREER), *Investigation of phase-changing falling liquid films sheared by a turbulent gas*
- **2017-2021**: TUBITAK 1001, *A theoretical-computational framework to model fluid lubrication*
- **2014-2016**: Imperial College Junior Research Fellowship 2015, *Unravelling the complexity in elasto-hydrodynamic lubrication*
- **2012-2014**: Marie Curie IntraEuropean Fellowship 2012, *Stability and transition to turbulence in polymeric shear flows*
- **2012-2013**: Göran Gustafsson Postdoctoral Fellowship in Science, *Stability of non-Newtonian shear flows*

Evidence of esteem

- **2020**: Mustafa Parlar Research Incentive Award
- **08/2019**: **Docentlik in Mechanical Engineering** (Qualification to become Associate Professor in Turkey)
- **09/2017-ongoing**: Visiting academic researcher at Imperial College London (UK)
- **09/2013-10/2013**: Invited researcher at EPFL (Lausanne, Switzerland)

Graduate students

- M.Sc.
  - Hammam Mohamed (09/2016-08/2019). Linear stability analysis of evaporating falling liquid films.
  - Humayun Ahmed (09/2017-08/2019). Non-linear modelling of non-Newtonian hydrodynamic lubrication.
  - Omair Mohamed (09/2017-11/2019). Spatio-temporal evolution of evaporating falling liquid films sheared by a gas.
  - Solmaz Khoshavaz (09/2017-12/2020). A spectral vanishing viscosity technique to model turbulent gas-liquid interfaces: the case of a falling liquid film.
  - Samuel Shari Gamaniel (01/2018-11/2020). Two-fluid cavitation modelling in lubricated contacts.
  - Mert Yusuf Çam (02/2019-ongoing). Direct numerical simulations of compressibile cavitating lubricants.
  - Ali Kerem Erdem (09/2019-ongoing). Particle dispersion and deposition in evaporating sessile droplets.
- Ph.D.
  - Hammam Mohamed (08/2019-ongoing). Direct numerical simulations of evaporating falling liquid films.
  - Humayun Ahmed (08/2019-ongoing). Modelling non-Newtonian elasto-hydrodynamic lubrication.
  - Omair Mohamed (11/2019-ongoing). Adjoint based variational data assimilation of falling liquid films.
  - Ayten Gülce Bayram (01/2020-ongoing). Crystallisation of active colloidal suspensions.

10 most important publications

- 10) T. Zaqarashvili, M. Albekioni, J. L. Ballester, Y. Bekki, **L. Biancofiore**, *et al.*, Rossby waves in Astrophysics, *Space Science Reviews*, **217**, 15, 2021
- 9) H. Mohamed & **L. Biancofiore**, Linear stability analysis of evaporating falling liquid films, *International Journal of Multiphase Flow*, **130**, 103354, 2020.
- 8) S. M. Mousavi, I. Kasaniuk, D. Kasanyuk, S. K. P. Velu, A. Callegari, **L. Biancofiore** & G. Volpe, Clustering of Janus Particles in Optical Potential Driven by Hydrodynamic Fluxes, *Soft Matter*, **15**, 5748-5759, 2019
- 7) **L. Biancofiore**, M. Giacopini & D. Dini, Interplay between wall slip and cavitation: A complementary variable approach, *Tribol. Int.*, **137**, 324-339, 2019.
- 6) F. Schmidt, A. Magazzù, A. Callegari, **L. Biancofiore**, F. Cichos, G. Volpe, Microscopic engine powered by critical demixing, *Phys. Rev. Let.*, **120**, 068004, 2018.
- 5) **L. Biancofiore**, L. Brandt & T. A. Zaki, Streaks instability in viscoelastic Couette flow, *Phys. Rev. Fluids.*, **2**. 043304, 2017.
- 4) **L. Biancofiore**, F. Gallaire & E. Heifetz, Interaction between counterpropagating Rossby waves and capillary waves in planar shear flows, *Phys. Fluids*, **27**, 044104, 2015.
- 3) **L. Biancofiore**, Crossover between two- and three-dimensional turbulence in spatial mixing layers, *J. Fluid Mech.*, **745**, 164-179, 2014.
- 2) **L. Biancofiore**, F. Gallaire & R. Pasquetti, Influence of confinement on a two-dimensional wake. *J. Fluid Mech.*, **688**, 297-320, 2011.
- 1) **L. Biancofiore** & F. Gallaire, The influence of shear layer thickness on the stability of confined two-dimensional wakes. *Phys. Fluids* **23**, 034103, 2011

Research/teaching activities in PoliBa

Lubrication is essential for the proper functioning of the mechanical components susceptible to degradation due to friction and wear. In particular we talk about hydrodynamic lubrication when a fluid introduced between two solid surfaces to mitigate this degradation. A "good" lubricant then minimizes the friction and wear but maximizing at the same time the load carrying capacity. Low values of the friction coefficient (i.e. friction over load) are required for ensure high performance of lubricants. Not surprisingly, lubricants are carefully designed and selected in order to satisfy the required load carrying capacity and other aspects specific to their application [1]. The formulation of commercial lubricants ranging from automotive engines to high-performance turbines is highly complex and includes not only base oils but also a variety of additives such as anti-wear agents, friction reducers, viscosity improvers, and so on. To enhance the durability and efficiency of lubricants as well as to meet sustainable development demands regarding fuel consumption and pollution reduction, development of efficient lubricant additives has attracted significant industrial and academic attention. From a rheological perspective commercial lubricants can present subtle non-Newtonian effects, such as shear thinning and viscoelasticity, especially at high shear rates which are quite common in tribological applications [2].

The use of polymeric additives to lubricants to improve their performance gained importance during the last years. For instance these oil-miscible polymer additives perform well as viscosity index improver and pour point depressants along with improvement of tribological properties [3, 4, 5, 6, 7]. Singh *et al.* [8] synthesized three copolymeric additives utilizing the C18 alkyl acrylate (C18Ac) and N,N-dimethylacrylamide (DMAA) monomers by varying the ratio between C18Ac:DMAA. All the synthesized polymers in polyol base oil revealed excellent performance in viscosity index improver, antiwear, antifriction, and anticorrosion. Particularly, polymer additive are used as viscosity modifier (VM) to counterbalance the loss in viscosity due to the temperature rise which occurs due to the friction at the wall [9]. There are three main features for a VM to improve thickening efficiency, the viscosity-temperature relationship, and shear stability. No current polymer additive is able to deliver optimum performance in all three areas, so the choice of the additive depends on which properties are most important for a given application. Several mechanisms have been proposed to explain the functionality of VMs. Two of them, coil expansion and polymer association, posit that the viscosity modification is due to the direct action of the polymer additive; the third mechanism relies on the additive altering the characteristics of the solvent. The role of viscoelasticity in lubricants with polymer additives is not yet completely resolved and there is a need of further analysis on this topic [10]. In particular when the solid deformation cannot be neglected, i.e. at high pressure and shear rate typical in industrial applications.

On the other hand contacts where soft lubrication is the fundamental governing mechanism are ubiquitous [11, 12, 13, 14]. Certainly, an important class of soft structures under lubricated conditions is found in biomechanics: soft bio-lubrication is omnipresent in our body as it occurs at different scales and in several systems, including cells, organs and tissues [15, 16]. As an example at the macro-scale, let us recall that human fingertip grasping and gripping are dramatically governed by the amount of liquid at the contact interface: this is extremely critical in the touchscreens era we are currently living [17, 18]. On the other hand, we should not underestimate the importance that soft lubrication has currently in industry. Indeed, a slow, but continuous shift from metals to polymers has been occurring in the last decades, given the cheaper cost, the lighter weight and the environmental compatibility offered by rubber-based materials and composites. Rubber bearings, seals, spacers, dampers are only possible examples of soft mechanical components [19, 20, 21, 22, 23]. Furthermore, at smaller scales, soft lubrication plays a crucial role in determining the operation and the dynamics of micro- and nano-actuators [24]. Despite the significant efforts in field of soft lubrication, there is still a lack of models in coupling viscoelastic solid deformation with lubricants with complex rheology, that would have interesting applications in biological systems. Just an en example, it is possible to recall the role of synovial fluid, which is largely non-Newtonian, in lubrication of human joints [25, 26].

The main goal of the visit of Dr. Luca Biancofiore (LB) is to foster a profitable research collaboration on the modelling of lubrication problems involving viscoelastic materials. During Dr. Biancofiore's stay we will combine the complementary skills of the his research group in Bilkent (i.e. the FluidFrame Lab) and the expertise on soft contacts, developed by Dr. Carmine Putignano (CP) in the framework of Tribolab, headed at Poliba by Prof. Giuseppe Carbone. The FluidFrame lab have developed in the recent years an efficient and accurate theoretical framework to simulate the behaviour of non-Newtonian fluids and in particular shear-thinning and viscoelastic lubricants [27, 28, 29, 30] in the framework of a TUBITAK (i.e. the Turkish National Research Agency) project concluded in January 2021. LB is currently starting in collaboration with researchers in Bilkent University (i.e. İlker Temizer and Aykut Erbaş) another project on non-Newtonian lubricants having the aim to (i) expand the current model to include 3D and thermal effects, (ii) couple of the models with models at the molecular scales and (iii) design optimal textured surfaces suitable for lubricants with complex rheology. On the other hand CP has built up a solid computational framework to deal with

applied mechanics problems involving viscoelastic soft solids [31, 32]. Therefore, the combination of the skills in Fluid and Solid Mechanics of the two research groups will create the optimal environment to build a unique computational framework able to accurately simulate the behaviour of non-Newtonian lubricants in a soft contact. To tackle this challenging goal we will divide the tasks in two workpackages (WPs) increasing the complexity step by step.

1. The first WP will last three months (from January to March 2022). The plan is to introduce the solid elastic deformation in the models and algorithm for viscoelastic lubricants developed in the FluidFrame Lab [29]. Note that researchers of the FluidFrame Lab have already developed models to study elastohydrodynamic lubrication (EHL) but considering shear-thinning lubricant films only [28]. In this WP with the help of CP and his collaborators we will improve the algorithm responsible of the elastic deformation of the solid making it suitable also for viscoelastic fluids. The results obtained in this WP will be the starting point of WP2.

2. The second WP will last four months (from April to July 2022). We will tackle the most challenging problem via combining the algorithms for simulating (i) the behaviour of viscoelastic lubricants developed at the FluidFrame Lab [29] and (i) and the viscoelastic deformation of the soft boundaries [32]. To our knowledge there are no models available in literature in which a contact lubricated with a viscoelastic fluid was coupled with viscoelastic deformation of the solids. Thus, at the end of this WP, we will provide unprecedented data including film thickness, friction, load, friction coefficients etc.

Aside from the industrial and technological impact of this research we expect at the of the visit to publish at least one journal paper in an International journal such as Tribology International, Journal of non-Newtonian Fluid Mechanics, Journal of Mechanics and Physics of Solids or Soft Matter. To finalise the redaction of this paper CP will apply for a visiting researcher position to visit Bilkent University (BU) at the end of 2022 (November/December 2022). But the beneficial effects of this visit will be not limited to the period of LB's visit to Bari. This collaboration will help to bridge a path for skills and transfer of knowledge between Polytechnical University of Bari (PoliBA) and BU. Thus, the visit will follow the vision of the European Research Area (ERA) to promote the free circulation of researchers, knowledge and technology. From this knowledge transfer not only the applicant and Dr. Putignano will benefit, but also (i) the members of the two research groups, such as MSc students, PhD students and postdoctoral researchers, (ii) the members of the Mechanical Engineering departments of PoliBa and BU and (iii) the entire PoliBa and BU research communities. Finally the scientific connections between PoliBA and BU can also strengthened by opening Erasmus and other exchange programs following LB's visit.

Furthermore, Dr. Biancofiore will give a series of seminars in the Mechanical Engineering Department of the Polytechnic University of Bari focusing on aspects relevant to Fluid Mechanics and Tribology. The titles of these seminars will be

1. *The kernel wave perspective: from geophysics to engineering.* This seminar will be held in January/February 2022.

2. *Complex rheology and engineering surface in hydrodynamic lubricated contacts.* This seminar will be held in April/May 2022.

3. *Evaporation in liquid films and sessile droplets.* This seminar will be held in June/July 2022.

While the first talk concerns mainly the past research on hydrodynamic stability conducted by LB during his experience at EPFL, KTH, Imperial College and University of Nice-Sophia Antipoles, the other two talks summarise the results obtained by his research group (i.e. the FluidFrame Lab) established at BU in 2016. Common topic between seminars 2 and 3 is the lubrication approximation whose application will be showed to be fundamental in different fields connected to Tribology, Fluid Mechanics and Chemical Engineering. In particularly, seminar 2 is directly connected to the proposed research. The language of the seminar will be English.

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