# Narsing Kumar Jha

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## Goals

Immediate:

- To join as a faculty member in a reputed institute and then teach the courses with utmost sincerity to transfer my understanding in the area and also sharpen my fundamentals. To carry out quality research in the state of the art laboratory to address the ambitious and deep problems in various fields of fluid dynamics. To make a significant contribution to the field, alongside developing new skills and further exposure to the different branches of fluid mechanics.

Long-term:

- To stay in academia and work on research problems of social and industrial significance while maintaining the interest in fundamental research. To teach, and pass on the knowledge and expertise to the next generation, and thus groom them to work in scientific research with confidence and dedication of the highest standard with moral code, and ethics.

## Employment History

Oct 2018 · · ·
- **PBC VATAT Post-doctoral Fellow** at Weizmann Institute of Science, Israel; Elastic instability of shear flows like plane Poiseuille and free shear flows

2017 – 2018
- **Post-doctoral Fellow** at Weizmann Institute of Science, Israel; Elastic instability

2016 – 2017
- **Post-doctoral Fellow** at DAMTP, Univ. of Cambridge; Environmental/fundamental flows

## Education

2009 – 2016
- **Direct Ph.D., Mechanical Engineering** Indian Institute of Science, Bangalore, GPA-7/8.
  Thesis title: Interaction of Bubbles with Vortical Structures
  More details at http://etd.iisc.ac.in/handle/2005/2677?show=full

2005 – 2009
- **B. Tech., Marine Engineering**, Institute of Technology and Marine Engg., Kolkata, India; CGPA-8.79/10 (Bronze)

## Achievements

- Awarded the PBC VATAT fellowship by Israeli government for my post-doctoral work on elastic instability in plane Poiseuille flow
- Secured all India rank 156 in Graduate Aptitude Test in Engineering (GATE) for Mechanical engineers conducted by IITs and IISc.
- Awarded Bronze medal for $3^{rd}$ rank in the Marine engineering at the university (WBUT, Kolkata) level.

## Skills

Experimental

**Flow visualization techniques:** • *Dye* - Used it for tracking vortex ring and mixing process in microfluidics for visualising elastic instability. • *Hydrogen bubble* - Used it to track the position of vortex ring.
**Particle Image Velocimetry:** Used time-resolved PIV for two phase turbulent channel flow, vortex ring interacting with a bubble, environmental flows to study the spreading of pollutant by human passage, micro high speed PIV for capturing elastic instability (spatial and temporal spectra along with flow structure) in plane-Poiseuille flow. Used visiometrics to analyse the vortex-bubble interaction.
**PTV, Hotwire and Micro LDV:** • PTV to track bubbles in the channel flow. • Hot wire anemometry for wind tunnel calibration. • LDV to measure spectra for elastic turbulence in micro-channel.
**Drag force measurement:** To measure the effect of superhydrophobic surface on wall drag in laminar boundary layer of water tunnel.
**Pressure measurements (absolute, differential, dynamic and acoustic):** To measure pressure drop in turbulent channel flows and also micro-channel, wall pressure spectra, rms of wall pressure fluctuations.
**Shadowgraphy and PLIF** • Shadowgraphy to characterise mixing in environmental flows. • PLIF to characterise mixing in micro-channel.
**High speed imaging and image processing:** Tracking of vortex ring and bubble.
**Conductivity measurement:** To characterise the ingress of pollutant in a room using salt and sugar water.
**Rheology of fluids:** Measuring elastic properties of fluid like viscosity and relaxation time using rheometer.

Programming

Matlab and Python: Most of the post-processing/analysis is carried out using it.

Softwares

• LabVIEW for signal and camera acquisition. • Solid Edge for designing turbulent channel. • Fluent(ANSYS) for solving the effect of bubble surface on wall drag in laminar flow. • Mathematica for solving some equations for modelling. • PIV processing using Dantec and DigiFlow (also for density fields). • Open source parallelised PIV code ran on super computers for robust statistics.

## Interests and expertise

Transition to Turbulence, Developed turbulence, Two phase flows, Bluff body flows, Hydraulic Jump, Free shear flows, Vorticity dynamics, Biological and complex/polymeric fluid flows, Drag reduction (Laminar, Turbulent and $\mu$-channel), Particles/Bubbles in turbulence and sedimentation, Stratified and environmental flows.

## Research Publications

### Journals:

**1. Narsing K. Jha**, R. N. Govardhan (2015). Interaction of a vortex ring with a single bubble: Bubble and vorticity dynamics. *Journal of Fluid Mechanics*, 773, pp 460-497;
Also featured in *Focus on Fluids* titled as *"About bubbles and vortex rings"* 780, pp 1-4

**2.** D. Dilip, **Narsing K. Jha**, Raghuraman N. Govardhan, M.S. Bobji (2014). Controlling air solubility to maintain "Cassie" state for sustained drag reduction. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 459, pp 217-224;
Also featured in newspaper (Indian express) titled as *"Research team at IISc develops innovative waterproof surface"*

**3.** Rajesh K. Bhagat, **Narsing K. Jha**, P. F. Linden, D. Ian Wilson (2018). On the origin of the circular hydraulic jump in a thin liquid film. *Journal of Fluid Mechanics* 851, R5, pp 1-11;

Featured/discussed in 39 news agency including BBC, Le Monde, and Fox news as *"A weird water behavior that intrigued Da Vinci finally has an explanation"*

**4. Narsing K. Jha**, A. Bhatt, R. N. Govardhan (2019). Effect of bubble distribution on wall drag in turbulent channel flow. *Experiments in Fluids*, 60(8), 127.

**5. Narsing K. Jha**, Lilian Darracq, Daria Frank, Paul F Linden (2019). Effect of human passage on air curtain effectiveness in the doorways of a building. *Journal of Fluid Mechanics (In $3^{rd}$ review)*

**6. Narsing K. Jha**, Victor Steinberg (2020). Universal coherent structures of elastic turbulence in straight channel with viscoelastic fluid flow. *Science Advances (Under review)*

**7. Narsing K. Jha**, Victor Steinberg (2020). Elastically driven Kelvin-Helmholtz-like instability in planar channel flow. *Nature (Under review)*

**8. Narsing K. Jha**, R. N. Govardhan (2019). Interaction of vortical structures with a single bubble in fully developed turbulent channel flow. *International Journal of Multiphase Flow (Under review)*

**9.** Vijay Kumar, Dong Yang, Atul Varshney, **Narsing K. Jha**, Victor Steinberg (2020). Elastic instability, flow relaminarization and suppression of vortices behind a cylinder for viscoelastic versus Newtonian fluid flow *Physical review letters (Under review)*

### Journals under preparation:

**10. Narsing K. Jha**, Daria Frank, Thomas van-Cann, Frans Cohn, Paul F Linden(2020). Comparison of water bath air curtain measurements with the real-scale air curtain installations. *Energy and Buildings*

**11. Narsing K. Jha**, Victor Steinberg (2020). Elastic instability and drag modification for an array of circular cylinders in viscoelastic flow *Physical review fluids*

### Conference proceedings (peer-reviewed and published):

**1.** P. F. Linden, R. K. Bhagat, N. K. Jha and D. I. Wilson, On the origin of the circular hydraulic jump: a differential analysis. *21st Australasian Fluid Mechanics Conference; Adelaide, Australia*, 10-13 December 2018.

**2.** Narsing K. Jha, Lilian Darracq, Daria Frank, Paul F Linden (2017). Effect of human walking on air curtain sealing in the doorway of an airtight building. *Air Infiltration and Ventilation Center (AIVC)*, Nottingham, UK, September 13 - September 14, 2017. pg - 937

### Conference abstracts:

Rajesh Kumar Bhagat, Narsing K. Jha, Paul Linden, D I Wilson, Effect of liquid surface tension on circular and linear hydraulic jumps; theory and experiments. *APS Division of Fluid Dynamics Annual Meeting*, Denver, Colorado, November 19 - November 21, 2017.

Rajesh Kumar Bhagat, Narsing K. Jha, Paul Linden, D I Wilson, On the origin of hydraulic jump. *UK Fluids 2018*, University of Manchester, UK, September 04 - September 06, 2018.

R. N. Govardhan, Narsing K. Jha, A single bubble in a turbulent channel flow: Towards understanding drag reduction. *APS Division of Fluid Dynamics Annual Meeting*, Oregon, MA, November 20 - November 22, 2016.

R. N. Govardhan, Narsing K. Jha, Vorticity dynamics in the interaction of a single bubble with a vortex ring. *APS Division of Fluid Dynamics Annual Meeting*, Boston, MA, November 22 - November 24, 2015.

Narsing K. Jha, R. N. Govardhan, Interaction of a vortex ring and a bubble. *APS Division of Fluid Dynamics Annual Meeting*, San Francisco, CA, November 23 - November 25, 2014.

Narsing K. Jha, R. N. Govardhan, Vorticity and bubble dynamics of a vortex ring interacting with a bubble. *IUTAM Symposium on Multiphase flows with phase change: challenges and opportunities*, IIT Hyderabad, India, December 08 - December 11, 2014.

## Miscellaneous experiences

**Teaching:** Teaching assistant for the 'Fluid Mechanics' course offered to graduate students at Indian Institute of Science, Bangalore for two academic semesters (2010 and 2014). As a part of it, I was involved in conducting tutorial sessions, correction of assignments, doubt clearing sessions and invigilation. I had also actively participated in laboratory demonstration and experimental set-up design for experimental fluid dynamics course.

**Research mentoring:** I have jointly supervised 12 undergraduate and master interns on different experimental fluid dynamics studies with Prof. Raghuraman N. Govardhan at IISc, Bangalore.
**Review:** Referee for *Journal of Fluid Mechanics*, *Journal of Fluids and Structures*
**Collaborative research:**
• Collaborated with Prof D I Wilson (University of Cambridge), on different aspects of hydraulic jump.
• Worked with Dr. Gaurav Tomar (IISc Bangalore), on structure near step of a 2D hydraulic jump at low $Re$ and high $Fr$.
• Collaborated with Prof Jaywant H Arakeri (IISc Bangalore), on zero pressure gradient two phase turbulent boundary layer.
• Worked with Prof. M. S. Bobji (IISc Bangalore), on sustainable drag reduction using super-hydrophobic surface in micro-channel.
**Industrial training:**
• Eight months workshop training in a ship yard (Hooghly Dock and Port Engineers Ltd., Government of India Undertaking) as a part of B. Tech. curriculum.
• On-board training on a ship (MV Maratha Deep) for familiarisation and hands on experience.
• As a research associate at DAMTP, I visited Biddle-BV, Netherlands and TNO, Delft to had a practical sense of the industry/large scale test facility and then planned the laboratory experiments which will help the industry for better design. During the visit, I also suggested some modifications into the existing design of industrial air curtain of Biddle-BV, Netherlands.
**Volunteering:**
• Volunteered every year in IISc (Bangalore) open days for planning, designing and displaying varieties of science experiments to the visitors.
• Served in organizing committee for college fest during undergraduate.

## Courses undertaken

**Fluids (Graduate)**: Fluid dynamics, Thermodynamics, Boundary layer, Solid and fluid phenomenons at small scale, Turbomachine, Transport processes, CFD, Experimental engineering, Mathematical and Numerical methods, Introduction to Hydrodynamic Instabilities, Turbulent flow, and Environmental flows (audit)

**Marine Engineering (Undergraduate)**: Fluid Mechanics, Naval architecture, Thermodynamics and thermal engineering, Ship design, Ship Machineries (Boiler, Turbine, Propeller, Cargo pump etc.), and Fluid power

## Projects

**Post-Doctoral:**

1. **"Elastic instability and turbulence at low Reynolds number in 2-D channel flow"**: Neither Elastic turbulence (ET) nor turbulent drag reduction (TDR) state for polymeric flow enjoys the good theoretical understanding as compared to the Newtonian turbulence. To understand it, we are using a long straight 2-D channel of large aspect ratio (width/height) of 7 with a height of 0.5 $mm$ and length of 1000 height for the investigation of elastic instabilities. We then tracked the evolution of unstable wave and transition mechanism in 2-D channel flows.
We are simultaneously using the pressure drop measurement, Laser Doppler velocimetry (LDV) and Particle image velocimetry (PIV) to measure the drag, high temporal resolution velocity from LDV and spatially resolved velocity from PIV to understand and couple the flow structure and the flow drag. We observed elastic wave and non-linear break down of flow structure, which lead to elastic turbulence and observed that elastic wave and turbulent state is coupled. We also studied the relation between wall friction and instability for different Weissenberg number ($Wi$ = polymer relaxation time/characteristic flow time).

2. **"Effect of human passage on air curtain sealing in the doorways of a building":** Heat and mass flow between cold and warm environments due to the pressure difference between both sides. This exchange causes a loss of energy and human comfort in the buildings. To minimize this heat and mass flux, an air curtain is often used as an artificial separation barrier. Although air curtains are mostly used to facilitate passage through the doorway, the effect of human and vehicle traffic on the stability and effectiveness of an air curtain is not well understood. We conducted laboratory experiments to examine the effect of a person passing through the curtain. We measured the flow rate through and the density across the doorway with and without the air curtain to calculate the effectiveness

of an air curtain, and found that the effectiveness is decreased by the passage of a person and that the effect increases with increasing walking speed. We visualized the jet and wake using dye to determine how the air curtain is deflected by the passage of a person. Time resolved particle image velocimetry were also done to study the flow structure and entrainment due to the interaction of the air curtain and wake of the cylinder. We also observed that the effect is independent of the direction of travel, a result of the relatively fast walking speed compared with the stack-driven exchange flow under normal circumstances. We studied it's feasibility in increasing containment effectiveness of isolated hospital rooms. Finally, we compared the lab scale measurement with the real scale air curtain measurements at TNO, Delft, Fluent simulation and theoretical models. Subsequently, we studied the effect of heavier curtain fluid on stability and effectiveness of air curtain.

***"Hydraulic jump":*** I have also worked on experimental investigation of the unsteady behavior of circular and two dimensional hydraulic jump and developed a theoretical model. Surfactant, Acetic-acid, and Propanol are separately mixed in water to vary the surface tension and viscosity of the liquid so that we could study the effect of fluid properties on hydraulic jump. For the first time, we showed that the surface tension is very important force for the hydraulic jump dynamics.

**Doctoral:** **"Interaction of bubbles with vortical structures":** Bubbly turbulent flows occur in a variety of industrial, naval and geophysical problems. In these flows, the bubbles in the flow interact with turbulence and/or vortical structures present in the continuous phase, resulting in bubble motion and deformation, and at the same time modifying the turbulence and/or vortical structures. Despite the fact that this has been a subject of interest for some time, mechanisms of bubble break-up due to turbulence and turbulence modulation due to bubbles are not well understood. To help understand this two-way coupled problem, we study in my thesis, the interaction of single and multiple bubbles with vortical structures; the thesis being broadly divided into three parts. In the first part, we study the interaction of a single bubble with a single vortical structure, namely a vortex ring, formed in the continuous phase (water). This may be thought of as a simplified case of the interaction of bubbles with vortical structures in any turbulent flow. We then proceed to study the interaction of a single bubble with vortical structures present in a fully developed turbulent channel flow, and then finally to the case of a large number of bubbles injected in to a fully developed turbulent channel. In all the cases, the bubble motions and deformations were visualized using high speed visualization, while the flow field information was obtained using time-resolved Particle-Image Velocimetery (PIV) in the first two cases, and from pressure drop measurements within the channel in the latter case.

**B.Tech. Project:** Project Report entitled "**Design and fabrication of cut-section model of four stroke S. I. Engine**": We designed and manufactured the cut-section in our workshop to demonstrate different motions in S. I. Engine.

## Personal details

DOB: 25/01/1988
Hobbies: Teaching science to young minds, Conducting fun physics/engineering experiments, Running (Quarter marathon and sprint), Swimming and water sports and Gardening.

## Selected references

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