

# Danny Raj M

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## RESEARCH INTERESTS

My research interests broadly encompass *understanding the non-linear interactions and collective dynamics in natural and artificial systems*. I wish to approach problems in engineering from two fronts: *a utilitarian front* where the idea is to explain the behavior of complex systems using computationally simple mathematical models that can be used for systematic design and control and *a dynamical-systems front* where the aim is to understand the physics of non-linear interactions and its impact on the collective behavior of the system. I would like to employ a combination of top-down and bottom-up approaches to study these problems. A *top-down approach* involves identifying the mathematical equations that govern the averaged dynamics of the system while a *bottom-up approach* perceives the observed system-level behaviour as, a consequence of the interactions at the entity level.

## TOPICS OF INTEREST:

Collective phenomena; droplet microfluidic systems; human traffic; collective social behavior in living agents; agent-based models, heat, mass and momentum transport in engineering systems.

## ACADEMIC RECORD

<b>PhD</b> (2011-2017)	Indian Institute of Technology Madras, Chennai, India Dept. of Chemical Engineering CGPA: 9.24/10
<b>B Tech</b> (2007- 2011)	A.C.Tech., Anna University, Chennai, India Dept. of Chemical Engineering CGPA: 8.1/10

## RESEARCH EXPERIENCE

- INSPIRE faculty fellowship: IISc Bengaluru, India (April 2018-present)
  - Understanding schooling in fish: *behavioral, glassy and hydrodynamic interactions [in collaboration with Dr. Vishwesh Guttal, CES, IISc]*
  - Engineering movement strategies in a dense crowd: insights from intruder movement through granular material etc. *[in collaboration with Prof. Kumaran, Chemical Engineering, IISc]*
  - Collective dynamics in Indian traffic *[in collaboration with Dr. Vishwesh Guttal, CES, IISc and Dr. Shashi Thutupalli, NCBS]*
  - Understanding the effect of intelligence of agents in the emergence of intelligence at the group level- **Independent research**
- Post-doctoral fellow: IIT Madras Chennai, India (April 2017- April 2018)
  - Dynamic modeling of an aluminum smelting process- *In collaboration with General Electric, Bengaluru* [Supervisor- Prof. Raghunathan Rengaswamy]
  - Experimental investigation of a spinning disk atomizer for production and collection of mono-dispersed particles- *IIT Madras Exploratory project* [Supervisor- Prof. Raghunathan Rengaswamy]
- Ph.D.: IIT Madras Chennai, India (July 2011-April 2017)
  - Advisor- Prof. Raghunathan Rengaswamy

- Thesis- *Drops as agents: understanding complex behavior in 2D microchannels*
- 4. Visiting scholar: University of West Virginia, Morgantown, USA (Sep 2014- Jan 2015)
  - Advisor- Dr. Debangshu Bhattacharya
  - Project- *Modeling health of refractories in gasifiers*
- 5. B.Tech.: AC Tech, Anna University, Chennai, India (July 2009- May 2011)
  - Advisor- Dr. Thiripuranthagan Sivakumar
  - Project- *Development and Characterization of Photocatalytic Materials for Degradation of aqueous Pollutants* (UGC, India sponsored)

## TEACHING EXPERIENCE

### Undergraduate course on Process control (2013, 2014)- *Prof. Raghunathan Rengaswamy*

1. Lectures on modeling physical systems for control, use of Laplace transforms in control.
2. Holding tutorials on a weekly basis for content taught the same week.
3. Setting up question papers for quizzes and end semester.

### Graduate course on Complex hydrodynamics (2016)- *Dr. Sumesh Thampi*

1. Holding tutorials for visualization of flow fields for point singularities in flow

## PEER-REVIEWED PUBLICATIONS

### Peer-reviewed journals:

1. Jitesh Jhavar, Richard G. Morris, U. R. Amith-Kumar, **M. Danny Raj**, Tim Rogers, Harikrishnan R., Vishweshha Guttal, ‘Noise-Induced Schooling of Fish’, accepted for publication in **Nature Physics** (January 2020).
2. C G Danny, **M Danny Raj**, Vvr Sai, ‘Ray optics model for U-bent fibre optic sensors’, accepted for publication in the **Journal of Lightwave technology** (November 2019).
3. **M. Danny Raj**, A. Gnanasekaran, R. Rengaswamy, “On the role of hydrodynamic interactions in the engineered assembly of droplet ensembles”, **Soft Matter**, vol. 15, 7863 (2019)
4. **M. Danny Raj** and R. Rengaswamy, “Interacting coalescence avalanches in a 2D droplet assembly”, **AICHE journal**, vol. 65, no. 3, 2019. (Available online: 08 November 2018)
5. **M. Danny Raj** and R. Rengaswamy, “Averaged model for probabilistic coalescence avalanches in two-dimensional emulsions: Insights into uncertainty propagation”, **Physical Review E**, vol. 95, no. 3, 032608, 2017.
6. **M. Danny Raj** and R. Rengaswamy, “Coalescence of drops in a 2D microchannel: critical transitions to autocatalytic behavior”, **Soft Matter**, vol. 12, no. 1, pp. 115-122, 2016.
7. S. Thiripuranthagan, **D. Raj**, and K. Kannan, “Photocatalytic Degradation of Congo-red on Silica Supported Ag Impregnated TiO<sub>2</sub>”, **J. Nanosci. Nanotechnol.** vol. 15, no. 6, pp. 4727–4733, 2015.
8. **M. D. Raj** and R. Rengaswamy, “Investigating Arrangement of Composite Drops in Two-Dimensional Microchannels Using Multi-Agent Simulations: A Design Perspective”, **Ind. Eng. Chem. Res.**, vol. 54, no. 43, pp. 10835-10842, 2015.
9. **M Danny Raj** and R. Rengaswamy, “Understanding drop-pattern formation in 2-D microchannels: a multi-agent approach”, **Microfluid. Nanofluidics**, vol. 17, no. 3, pp. 527–537, Jan. 2014.

### Conference proceedings:

1. **Danny Raj M** and R. Rengaswamy, “Understanding Control in Microchannels to Manipulate Drop-Drop Interactions”, in 2014 European Control Conference (ECC), 2014, pp. 1055–1060.
2. Christina G Danny, **M Danny Raj**, Vvr Sai, “Ray Optics Model for Light Attenuation in U-Bent Fibre Optic Sensors”, in IEEE SENSORS 2018, New Delhi, 2018, pp. 1-4.

## To be submitted/under review:

1. Danny Raj M and Kumaran V, 'Moving through a crowd: a nature inspired traffic rule', to be submitted.

## INVITED TALKS

1. A talk on, '*Understanding collective behavior of drops in 2D microchannels: an agent-based approach*', in the Department of chemical engineering, University of Florida, Gainesville on the 17<sup>th</sup> Nov 2015.
2. A lecture on, '*A peek into chemical engineering*', to students in their high school and first year in bachelors, as part of Sanjog 2017, a program for children of the staff of Indian Army, held in IIT Madras on 6<sup>th</sup> June 2017.
3. An invited talk at the 1<sup>st</sup> Indian Process Systems Engineering (IPSE) at IIT Madras on, '*A systems approach to droplet microfluidics*', 18<sup>th</sup> August 2019.
4. A lecture on, '*Simulating complex systems with MATLAB*', research scholars from Mathematics, Applied Mathematics and Computer science as a part of the workshop IWDAM 2019 (International workshop on Data Analytics and MATLAB) September 2019.
5. A talk on, '*Moving through a crowd: nature inspired traffic rule*', in the Center for Ecological Sciences, IISc Bangalore on 13<sup>th</sup> September 2019.
6. A lecture on, '*Droplet microfluidics: the science and engineering of small-scale flows*', for undergraduates and faculty at the Department of Chemical engineering, MVJ college of Engineering, Bangalore on 21<sup>st</sup> September 2019.

## CONFERENCES

1. Danny Raj M and Kumaran V, '*Moving through a crowd: a nature inspired traffic rule*', **Compflu 2019**, IISER Bhopal (December 2019)
2. Danny Raj M, Gnanasekaran A., Rengaswamy R., '*A systems approach to droplet microfluidics*', at the **1<sup>st</sup> Indian Process Systems Engineering (IPSE) conference**, IIT Madras (August 2019)
3. Danny Raj M, '*Traffic of agents that remember*', presented as a poster in the **Collective behavior conference**, held in ICTP, Trieste, Italy (May 2018)
4. Sivakumar P, Balu B, Danny Raj M, Rengaswamy R, '*Soft matter meets machine learning: insights into the stability of poly-disperse emulsions*', presented as a contributed work in **Compflu-17** in IIT Madras (Dec 2017)
5. Danny Raj M, Rengaswamy R, '*Coalescence avalanches in 2D emulsions: a stochastic approach*', presented in **APS-DFD 68<sup>th</sup> annual meeting** at Boston, USA (Nov 2015).
6. Danny Raj M, Rengaswamy R, '*Agent based models to study complex drops: self-organization and propagated coalescence*', presented in **AIChE Annual Meet** at Salt Lake City, Utah, USA (Nov 2015)
7. Sandiri S, Danny Raj M, Das L, Maddala J, Rengaswamy R, '*Coding and decoding drops using microfluidic loops: an analytical approach*', presented in **AIChE Annual Meet** at Atlanta, USA (Nov 2015)
8. Danny Raj M, Rengaswamy R, '*Complex traffic of drops in 2D microchannels: self-organization, periodicity and reversibility*', presented in **APS-DFD 67<sup>th</sup> annual meeting** at San Francisco, USA (Nov 2014).
9. Danny Raj M, Rengaswamy R, '*Understanding propagated coalescence of drops in 2d microchannels: A Monte-Carlo approach*', presented in **AIChE Annual Meet** at Atlanta, USA (Nov 2014).
10. Danny Raj M, Rengaswamy R, '*Collective behavior of drops in microchannels: Non-linearity, self-organization and criticality*', presented in **DDAP 08: Dynamic Days Asia Pacific 08** at IIT-Madras-IMSC, Chennai, India (July 2014)
11. Danny Raj M, Rengaswamy R, '*Understanding Control in Microchannels to Manipulate Drop-Drop Interactions*', presented in **ECC: 13<sup>th</sup> European Control Conference** at Strasburg, France (June 2014) [DST sponsored].
12. Danny Raj M, Rengaswamy R, '*Understanding Drop-Drop Contacting Patterns in a Microchannel*', presented in **AIChE Annual Meet** at San Francisco, California, USA (Nov 2013)

13. Danny Raj M, Rengaswamy R, '*Understanding emergent behavior of drops in microchannels- Interacting drop-traffic model*', presented in **AMN- Advances in Microfluidics and Nanofluidics**, at University of Notre Dame, Indiana, USA (May 2013)
14. Danny Raj M, Rengaswamy R, '*Understanding the dynamics of drops in a microchannel using simple models: Application to reactor design*', presented in **Mackie- International Workshop on Mathematics in Chemical Kinetics and Engineering** at IIT Madras (Feb 2013)
15. Danny Raj M, Krishnadoss V, Venkatesan V, Kannan K, Thiripuranthagan S., '*Development and Characterization of Photocatalytic Materials for Degradation of Aqueous Pollutants*', presented **20<sup>TH</sup> National Symposium on Catalysis for Energy Conversion and Conservation of Environment** at IIT-M, India (Dec 2010).

## HONORS AND AWARDS

1. Best presentation award in the '*Present your research in two minutes*' competition held in IIT Madras during **Research scholars' day (2016)**.
2. Best presentation award as chosen by the editor in chief of the *Journal of fluid mechanics (JFM)* during the **JFM symposium- Chennai edition (2017)**
3. Awarded the **DST INSPIRE fellowship** (July 2017 call), offered by Department of science and technology, India (DST).

## INTERNSHIP PROJECTS

1. Orchid Chemicals and Pharmaceuticals Ltd, Alathur, Tamilnadu, India (**June 2010**)
  - **Project:** Formulating a kinetic model to predict the formation of a Cephalosporin product
2. Indian Space Research Organization Inertial Systems Unit (IISU), Kerala, India (**June 2008**)
  - **Project:** Study of the effect of etchant buffer solutions on the rate of etching and roughness of quartz

## EXTRA-CURRICULAR ACTIVITIES

1. Have passed the grade 8 piano and grade 5 theory (with distinction) Examinations conducted by the *Associated Board of the Royal School of Music (ABRSM), London*.
2. I conduct choirs, involve myself in church choral music where I play the piano and sing bass.

## COMPUTATIONAL SKILLS

Packages: MATLAB, Mathematica, C

## ACKNOWLEDGEMENT

I do hereby declare that the information and facts stated herein above are true and complete to the best of my knowledge and belief.

DANNY RAJ M