

# HARSHA S. BHAT

Ecole Normale Supérieure CNRS Scientist  
Ecole Polytechnique Teaching Professor



PSL



## PERSONAL INFORMATION

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## EDUCATION

École Normale Supérieure, France	H. D. R. <sup>†</sup>	Supershear Earthquakes	2021/01
Harvard University, USA	Ph. D.*	Mechanical Sciences	2007/06
Harvard University, USA	M. S.	Engineering Sciences	2002/06
NITK, India	B. E.	Civil Engineering	2001/06

<sup>†</sup> Habilitation à Diriger des Recherches \* Supervised by Prof. J. R. Rice & Dr. R. Dmowska

## CURRENT POSITION

École Normale Supérieure, France	2016/05 ▶ Present	CNRS Research Scientist
Ecole Polytechnique, France	2022/09 ▶ Present	Teaching Professor (PCC)
NISER, India	2021/11 ▶ 2023/11	Visiting Professor

## PAST POSITIONS

Institut de Physique du Globe de Paris, France	2012/01 ▶ 2016/05	CNRS Research Scientist
University of Southern California, USA	2010/03 ▶ 2011/12	Asst. Professor (Research)
University of Southern California, USA	2007/11 ▶ 2010/03	Post Doctoral Fellow
California Institute of Technology, USA	2007/11 ▶ 2010/03	Visitor in Aeronautics
Harvard University, USA	2007/05 ▶ 2007/10	Post Doctoral Fellow
Harvard University, USA	2001/11 ▶ 2007/05	Grad. Research Associate

## FUNDING & GRANTS<sup>†</sup>

- 2021-2025 ▶ 2M€ ERC Consolidator Grant, PERSISMO (Grant No. 865411)
- 2018-2018 ▶ 25k€ ENS Actions Incitatives
- 2017-2017 ▶ 6k€ TelluS INSU - action ALEAS
- 2023-2027 ▶ 100k€ ANR SMEC
- 2023-2026 ▶ 100k€ ANR Univ. Tokyo SESAME
- 2023-2025 ▶ 66k€ SPARC Grant India

## HONORS AND AWARDS

- 2018 CNRS Award for Doctoral Supervision and Research
- 2018 Grand Prix Michel Gouilloud Schlumberger, French Academy of Sciences

- 2006 Harvard University Certificate of Distinction in Teaching
- 2004 Harvard University Certificate of Distinction in Teaching
- 2003 Harvard University Certificate of Distinction in Teaching

## CURRENT TEACHING RESPONSIBILITIES AT ECOLE POLYTECHNIQUE†

MEC430 Mécanique du Milieu continu 1: Contrôle Correction (Fall 2024)  
 MEC431 Mécanique des Solides: PC sections (Spring 2023)  
 MEC568 Mécanique de la Rupture: PC sections (Spring 2023, 2024)  
 MEC592 Mécanique des matériaux et des structures: Internships (Spring 2024)

## STUDENTS & POSTDOCS

A majority of the people below were/are being co-advised/co-supervised with colleagues from various institutes in EU, USA and France.

### Postdoctoral Associates

Ankit Gupta (India)	2024-	
Navid Kheirdast (Iran)	2022-	
Michelle Almakari (France)	2021-2023	
Carlos Villafuerte (Mexico)	2021-2023	Asst. Prof. UNAM
Ekeabino Momoh (Nigeria)	2019-2022	AXA Postdoc Fellow
Lucile Bruhat (France)	2018-2021	Natural Catastrophe Risk Analyst at AXA
Lisa Gordeliy (Russia)	2019-2019	Post Doctoral fellow at Ecole Polytechnique
Marion Y. Thomas (France)	2014-2016	CNRS Scientist at Sorbonne Université

### PhD Students

Bharath Shanmugasundaram (India)	2024-2027	
Yishuo Zhou (China)	2024-2027	
Thomas Melkior (France)	2023-2026	
Caiyuan Fan (China)	2023-2027	
Jinhui Cheng (China)	2021-2024	
Augustin Thomas (France)	2020-2023	Postdoc BRGM
Joseph Flores Cuba (Peru)	2020-2023	
Claudia Hulbert (France)	2018-2021	CEO Geolabe
Samson Marty (France)	2017-2020	Postdoc at Caltech
Marshall A. Martinez (USA)	2014-2019	Engineer at Joby Aviation
Kurama Okubo (Japan)	2015-2018	Research Scientist at NIED, Japan
Pierre Romanet (France)	2014-2017	Research Scientist at NIED, Japan
Vahe Gabuchian (USA)	2010-2015	Research Scientist at Caltech
François X. Passelègue (France)	2011-2014	CNRS Scientist at GeoAzur, Nice
Jonathan Mihaly (USA)	2008-2013	Jet Propulsion Laboratory
Michael Mello (USA)	2007-2012	Teaching Professor at Caltech

### Undergraduate and Masters Interns

Valentin Marnat	2022	Phillipe Danre	2017
Roxane Ferry	2021	Eleni Kolokytha	2015
Jinhui Cheng	2020	Victor Barolle	2015
Phillipe Danre	2019	Kurama Okubo	2014
Roxane Ferry	2019	Thibaut Perol	2013
Hugo Lestrelin	2019	Lucile Bruhat	2012
Nicolas Mercury	2018	Marion Olives	2004
Luc Illien	2018	Sonia Fliss	2003

## PAST TEACHING ACTIVITIES<sup>†</sup>

- |  |   |
|--|---|
| 1) Mécanique des Milieux Continus              | 8) Complex and Fourier Analysis                 |
| 2) Active Faults : Geometry                    | 9) Computational Solid and Structural Mechanics |
| 3) Seismic Ruptures and Scaling Laws           | 10) Solid Mechanics                             |
| 4) Introduction to Rock Physics                | 11) Introduction to the Mechanics of Solids     |
| 5) Mathematical Methods in the Sciences        | 12) Mechanics of Fracture                       |
| 6) Environmental Risks and Disasters           | 13) Advanced Geomechanics                       |
| 7) Ordinary and Partial Differential Equations | 14) Mécanique de la Fracturation                |

<sup>†</sup> Classes taught with various colleagues at Harvard, Caltech, IPGP, ENS

## ORGANIZATION OF SCIENTIFIC MEETINGS

- Apr 2024: Across the time scales, from earthquakes to earthquake cycle: EGU 2024
- Apr 2023: Across the time scales, from earthquakes to earthquake cycle: EGU 2023
- Jun 2019: Coupled Processes In Fracture Propagation In Geo-Materials: From Hydraulic Fractures To Earthquakes: CISM Advanced School, Udine, Italy
- Apr 2015: Seismological Society of America, Multiscale Modeling and Characterization of Fragmentation and Damage Patterns in Fault Zones
- Dec 2014: American Geophysical Union, Fault Zone Properties And Processes During Dynamic Ruptures

## INSTITUTIONAL RESPONSIBILITIES

- 2018-2024: Team Leader of Faults & Earthquakes Group, ENS
- 2018-2019: Co-organizer of the Internal Seminar, ENS

## EDITORIAL RESPONSIBILITIES

Member of the Editorial Board for the **Journal of Theoretical Computational and Applied Mechanics**

## REVIEWING ACTIVITIES

American Geophysical Union   Seismological Society of America   International Journal of Fracture   Geological Society of America   Science   Nature   Journal of the Mechanics and Physics of Solids   European Journal of Mechanics - A/Solids   Earth and Planetary Science Letters   Geophysical Research Letters   Journal of Structural Geology   Proceedings of the National Academies of Science, USA   Geology   Geophysical Journal International   Journal of Applied Mechanics   National Science Foundation   European Research Council   Nature Communications   Nature Geoscience   Science Advances

## BOOKS

Thomas, M. Y., Mitchell, T. M., **Bhat, H. S.**, eds. (2017b). *"Fault Zone Dynamic Processes : Evolution of Fault Properties During Seismic Rupture, Geophysical Monograph 227"*. American Geophysical Union (AGU). DOI: 10.1002/9781119156895.

Bizzarri, A., **Bhat, H. S.**, eds. (2012). *"The mechanics of faulting: From laboratory to earthquakes"*. Research Signpost.

## BOOK CHAPTERS

Thomas, M. Y., **Bhat, H. S.**, (2022b). *"Loi de friction et modélisation numérique du cycle sismique"*. in [Le Cycle Sismique](#). Ed. by F. Rolandone. ISTE-Wiley.

Thomas, M. Y., **Bhat, H. S.**, (2022a). *"Friction Laws and Numerical Modeling of the Seismic Cycle"*. in [The Seismic Cycle: From Observation to Modeling](#). Ed. by F. Rolandone. ISTE-Wiley.

To be submitted by June 2024

- Momoh, E., **Bhat, H. S.**, Tait, S., Gerbault, M., (2024). “Towards thermomechanical modelling of lithospheric compression including the contribution of volumetric deformation to dissipative heating and localization”. [subm. Geophys. J. Int.](#)
- Cheng, J., Almakari, M., Peruzzo, C., Lecampion, B., **Bhat, H. S.**, (2024b). “The effect of 3D fault interactions on slow and fast earthquakes”. [to be submitted for GRL.](#)
- Cheng, J., Almakari, M., Peruzzo, C., Lecampion, B., **Bhat, H. S.**, (2024a). “FASTDASH, a Quasi-dynamic 3D Seismic Cycle Model by Using Boundary Element Method with H-matrices”. [to be submitted for GJI.](#)
- Thomas, M. Y., **Bhat, H. S.**, Dubernet, P., (2024b). “Combined effects of fault roughness and off-fault damage on earthquake dynamics”. [to be submitted.](#)
- Ferry, R., Thomas, M. Y., **Bhat, H. S.**, Jeandet-Ribes, L., Dubernet, P., (2024). “Depth variation of co-seismic damage”. [to be submitted.](#)
- Almakari, M., Kheirdast, N., Villafuerte, C. D., Thomas, M. Y., **Bhat, H. S.**, Cheng, J., Dubernet, P., (2024). “Full spectrum of slip dynamics of a fault zone: Source Dynamics”. [to be submitted.](#)
- Villafuerte, C. D., Almakari, M., Kheirdast, N., Thomas, M. Y., **Bhat, H. S.**, Cheng, J., Dubernet, P., (2024). “Full spectrum of slip dynamics of a fault zone: Synthetics”. [to be submitted.](#)
- Kheirdast, N., Almakari, M., Villafuerte, C. D., **Bhat, H. S.**, Cheng, J., Dubernet, P., (2024). “Full spectrum of slip dynamics of a fault zone: Energy Budget”. [to be submitted.](#)
- Flores-Cuba, J., Thomas, M. Y., **Bhat, H. S.**, Jolivet, L., Dubernet, P., (2024). “Effect on off-fault damage on stepovers”. [in prep.](#)
- Thomas, M. Y., Preca Trapani, R., **Bhat, H. S.**, Klinger, Y., Dubernet, P., (2024a). “Investigating the Impact of Complex Fault Zone Geometries on Seismic Rupture Propagation”. [to be submitted.](#)

## Published

- Petit, L., Olive, J.-A., Schubnel, A., Le Pourhiet, L., **Bhat, H. S.**, (2024). “A brittle constitutive law for long-term tectonic modeling based on sub-critical crack growth”. [to appear in Geochem. Geophys. Geosyst.](#)
- Jeandet-Ribes, L., Thomas, M. Y., **Bhat, H. S.**, (2023). “On the importance of setting 3-D stress field in simulations of on- and off-fault deformation”. [Geophys. J. Int.](#) 235.3, pp. 2962–2978. DOI: 10.1093/gji/ggad401.
- Marty, S., Schubnel, A., **Bhat, H. S.**, Aubry, J., Fukuyama, E., Latour, S., Nielsen, S., Madariaga, R., (2023). “Nucleation of laboratory earthquakes: quantitative analysis and scalings”. [J. Geophys. Res.](#) 128.e2022JB026294. DOI: 10.1029/2022JB026294.
- Amlani, F., **Bhat, H. S.**, Simons, W. J. F., Schubnel, A., Vigny, C., Rosakis, A. J., Efendi, J., Elbanna, A., Dubernet, P., Abidin, H. Z., (2022). “Supershear shock front contribution to the tsunami from the 2018 Mw 7.5 Palu, Indonesia earthquake”. [Geophys. J. Int.](#) 230, pp. 2089–2097. DOI: 10.1093/gji/ggac162.
- Jara, J., Bruhat, L., Thomas, M. Y., Antoine, S., Okubo, K., Klinger, Y., Jolivet, R., **Bhat, H. S.**, (2021). “Signature of transition to supershear rupture speed in coseismic off-fault damage zone”. [Proc. R. Soc. A.](#) 477, p. 20210364. DOI: 10.1098/rspa.2021.0364.

- Elbanna, A., Abdelmeguid, M., Ma, X., Amlani, F., **Bhat, H. S.**, Synolakis, C., Rosakis, A. J., (2021). “Anatomy of Strike Slip Fault Tsunami Genesis”. *Proc. Natl. Acad. Sci. USA*. DOI: 10.1073/pnas.2025632118.
- Bhat, H. S.** (2021). “Supershear Earthquakes”. PhD thesis. Habilitation à Diriger des Recherches, Ecole Normale Supérieure.
- Jeandet-Ribes, L., Cubas, N., **Bhat, H. S.**, Steer, P., (2020). “Response of a single fault to transient normal stress change, and implications of large erosional events on the seismic cycle”. *Geophys. Res. Lett.* 47.e2020GL087631. DOI: 10.1029/2020GL087631.
- Jolivet, R, Simons, M, Duputel, Z, Olive, J.-A., **Bhat, H. S.**, Bletery, Q., (2020). “Interseismic Loading of Subduction Megathrust Drives Long-Term Uplift in Northern Chile”. *Geophys. Res. Lett.* 47.8, e2019GL085377. DOI: 10.1029/2019GL085377.
- Okubo, K., Rougier, E, Lei, Z., **Bhat, H. S.**, (2020). “Modeling earthquakes with off-fault damage using the combined finite discrete element method”. *J. Comp. Part. Mech.* DOI: 10.1007/s40571-020-00335-4.
- Okubo, K., **Bhat, H. S.**, Rougier, E., Marty, S., Schubnel, A., Lei, Z., Knight, E. E., Klinger, Y., (2019). “Dynamics, radiation and overall energy budget of earthquake rupture with coseismic off-fault damage”. *J. Geophys. Res.* 124. DOI: 10.1029/2019JB017304.
- Marty, S., Passelègue, F. X., Aubry, J., Schubnel, A., **Bhat, H. S.**, Madariaga, R., (2019). “Origin of high-frequency radiation during laboratory earthquakes”. *Geophys. Res. Lett.* 46. DOI: 10.1029/2018GL080519.
- Aubry, J., Passelègue, F. X., Deldicque, D., Girault, F., Marty, S., Lahfid, A., **Bhat, H. S.**, Escartin, J., Schubnel, A., (2018). “Frictional heating processes and energy budget during laboratory earthquakes”. *Geophys. Res. Lett.* 45. DOI: 10.1029/2018GL079263.
- Klinger, Y. (2018). “Earthquake damage patterns resolve complex rupture processes”. *Geophys. Res. Lett.* DOI: 10.1029/2018GL078842.
- Cruz-Atienza, V. M., Villafuerte, C. D., **Bhat, H. S.**, (2018). “Rapid tremor migration and pore-pressure waves in subduction zones”. *Nat. Commun.* 9.1, p. 2900. DOI: 10.1038/s41467-018-05150-3.
- Thomas, M. Y., **Bhat, H. S.**, (2018). “Dynamic evolution of off-fault medium during an earthquake: a micromechanics based model”. *Geophys. J. Int.* 214.2, pp. 1267–1280. DOI: 10.1093/gji/ggy129.
- Romanet, P., **Bhat, H. S.**, Jolivet, R., Madariaga, R., (2018). “Fast and slow earthquakes emerge due to fault geometrical complexity”. *Geophys. Res. Lett.* DOI: 10.1029/2018GL077579.
- Gabuchian, V., Rosakis, A. J, **Bhat, H. S.**, Madariaga, R., Kanamori, H., (2017). “Experimental evidence that thrust earthquake ruptures might open faults”. *Nature* 545.336–339. DOI: 10.1038/nature22045.
- Thomas, M. Y., **Bhat, H. S.**, Klinger, Y., (2017a). “Effect of Brittle off-fault Damage on Earthquake Rupture Dynamics”. in *Fault Zone Dynamic Processes : Evolution of Fault Properties During Seismic Rupture, Geophysical Monograph 227*. Ed. by M. Y. Thomas, H. S. Bhat, and T. M. Mitchell. American Geophysical Union (AGU), pp. 255–280. DOI: 10.1002/9781119156895.ch14.
- Passelègue, F. X., Latour, S., Schubnel, A., Nielsen, S., **Bhat, H. S.**, Madariaga, R., (2017). “Precursory Processes during Laboratory Earthquakes”. in *Fault Zone Dynamic Processes : Evolution of Fault Properties During Seismic Rupture, Geophysical Monograph 227*. Ed. by M. Y. Thomas, H. S. Bhat, and T. M. Mitchell. American Geophysical Union (AGU). Chap. 12, pp. 229–242. DOI: 10.1002/9781119156895.ch12.
- Perol, T., **Bhat, H. S.**, (2016). “Micromechanics based permeability evolution in brittle materials at high strain rates”. *Pure Appl. Geophys.* Pp. 1–12. DOI: 10.1007/s00024-016-1354-4.

- Passelègue, F. X., Schubnel, A., Nielsen, S., **Bhat, H. S.**, Deldicque, D., Madariaga, R., (2016). “*Dynamic rupture processes inferred from laboratory microearthquakes*”. *J. Geophys. Res.* 121. DOI: 10.1002/2015JB012694.
- Mello, M., **Bhat, H. S.**, Rosakis, A. J., (2016). “*Spatiotemporal properties of sub-Rayleigh and supershear rupture velocity fields : Theory and Experiments*”. *J. Mech. Phys. Solids* 93, pp. 153–181. DOI: 10.1016/j.jmps.2016.02.031.
- Vallage, A., Klinger, Y., Grandin, R., **Bhat, H. S.**, Pierrot-Deseilligny, M., (2015). “*Inelastic surface deformation during the 2013 Mw 7.7 Balochistan, Pakistan, earthquake*”. *Geology* 43.12, pp. 1079–1082. DOI: 10.1130/G37290.1.
- Frank, W. B., Shapiro, N. M., Husker, A. L., Kostoglodov, V., **Bhat, H. S.**, Campillo, M., (2015). “*Along-fault pore-pressure evolution during a slow-slip event in Guerrero, Mexico*”. *Earth Planet. Sc. Lett.* 413, pp. 135–143. DOI: 10.1016/j.epsl.2014.12.051.
- Siriki, H., **Bhat, H. S.**, Lu, X., Krishnan, S., (2015). “*A Laboratory Earthquake-Based Stochastic Seismic Source Generation Algorithm for Strike-Slip Faults*”. *Bull. Seism. Soc. Am.* 105.4, pp. 2250–2273. DOI: 10.1785/0120140110.
- Mello, M., **Bhat, H. S.**, Rosakis, A. J., Kanamori, H., (2014). “*Reproducing The Supershear Portion Of The 2002 Denali Earthquake Rupture In Laboratory*”. *Earth Planet. Sc. Lett.* 387, pp. 89–96. DOI: 10.1016/j.epsl.2013.11.030.
- Passelègue, F. X., Schubnel, A., Nielsen, S., **Bhat, H. S.**, Madariaga, R., (2013). “*From Sub-Rayleigh to Supershear Ruptures During Stick-Slip Experiments on Crustal Rocks*”. *Science* 340.6137, pp. 1208–1211. DOI: 10.1126/science.1235637.
- Bhat, H. S.**, Rosakis, A. J., Sammis, C. G., (2012). “*A Micromechanics Based Constitutive Model For Brittle Failure at High Strain Rates*”. *J. Appl. Mech.* 79.3. DOI: 10.1115/1.4005897.
- Bhat, H. S.**, Sammis, C. G., Rosakis, A. J., (2011). “*The Micromechanics of Westerley Granite at Large Compressive Loads*”. *Pure Appl. Geophys.* 168.12, pp. 1–18. DOI: 10.1007/s00024-011-0271-9.
- Bhat, H. S.**, Biegel, R. L., Rosakis, A. J., Sammis, C. G., (2010). “*The Effect of Asymmetric Damage on Dynamic Shear Rupture Propagation II: With Mismatch in Bulk Elasticity*”. *Tectonophysics* 493.3, pp. 263–271. DOI: 10.1016/j.tecto.2010.03.016.
- Biegel, R. L., **Bhat, H. S.**, Sammis, C. G., Rosakis, A. J., (2010). “*The Effect of Asymmetric Damage on Dynamic Shear Rupture Propagation I: No Mismatch in Bulk Elasticity*”. *Tectonophysics* 493.3, pp. 254–262. DOI: 10.1016/j.tecto.2010.03.020.
- Mello, M., **Bhat, H. S.**, Rosakis, A. J., Kanamori, H., (2010). “*Identifying the unique ground motion signatures of supershear earthquakes: Theory and experiments*”. *Tectonophysics* 493, pp. 297–326. DOI: 10.1016/j.tecto.2010.07.003.
- Templeton, E. L., **Bhat, H. S.**, Dmowska, R., Rice, J. R., (2010). “*Dynamic rupture through a branched fault configuration at Yucca Mountain and resulting ground motions*”. *Bull. Seism. Soc. Am.* 100.4, pp. 1485–1497. DOI: 10.1785/012009012110.1785/0120090121.
- Harris, R. A. (2009). “*The SCEC/USGS dynamic earthquake rupture code verification exercise*”. *Seismol. Res. Lett.* 80.1. DOI: 10.1785/gssr1.80.1.119.
- Sammis, C. G., Rosakis, A. J., **Bhat, H. S.**, (2009). “*Effects of Off-fault Damage on Earthquake Rupture Propagation: Experimental Studies*”. *Pure Appl. Geophys.* 166. DOI: 10.1007/s00024-009-0512-3.



- Templeton, E. L., Baudet, A., **Bhat, H. S.**, Dmowska, R., Rice, J. R., Rosakis, A. J., Rousseau, C. E., (2009). “*Finite Element Simulations of Dynamic Shear Rupture Experiments and Dynamic Path Selection Along Kinked and Branched Faults*”. *J. Geophys. Res.* B08304. DOI: 10.1029/2008JB006174.
- Dunham, E. M., **Bhat, H. S.**, (2008). “*Attenuation of radiated ground motion and stresses from three-dimensional supershear ruptures*”. *J. Geophys. Res.* 113.B08319. DOI: 10.1029/2007JB005182.
- Bhat, H. S.**, Dmowska, R., King, G. C. P., Klinger, Y., Rice, J. R., (2007a). “*Off-fault damage patterns due to supershear ruptures with application to the 2001  $M_w$  8.1 Kokoxili (Kunlun) Tibet earthquake*”. *J. Geophys. Res.* B06301. DOI: 10.1029/2006JB004425.
- Bhat, H. S.**, Olives, M., Dmowska, R., Rice, J. R., (2007b). “*Role of fault branches in earthquake rupture dynamics*”. *J. Geophys. Res.* B11309. DOI: 10.1029/2007JB005027.
- Bhat, H. S.** (2007). “*Role of Geometric Complexities and Off-Fault Damage in Dynamic Rupture Propagation*”. PhD thesis. Harvard University.
- Fliss, S., **Bhat, H. S.**, Dmowska, R., Rice, J. R., (2005). “*Fault branching and rupture directivity*”. *J. Geophys. Res.* B06312. DOI: 10.1029/2004JB003368.
- Bhat, H. S.**, Dmowska, R., Rice, J. R., Kame, N., (2004). “*Dynamic slip transfer from the Denali to Totschunda faults, Alaska: Testing theory for fault branching*”. *Bull. Seism. Soc. Am.* 94, S202–S213. DOI: 10.1785/0120040601.