Date 26-09-2021
Contact person Lizzy Groote, Managementassistant, 22, F166
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Subject KIND Synergy Application

Prof. Dr. Mazhar Ali
Faculty of Applied Sciences
Dept. of Quantum Nanoscience
Building 22 Office E120
M.N.Ali@tudelft.nl
Visiting address
Lorenztweg1
2628 CJ Delft
Postal address
P.O. Box 5031
2600 GA Delft
The Netherlands

Dear members of the Kavli Seed Funding committee,

Enclosed please find our application for the 2022 KIND Synergy Program. Our research proposal is titled, "*Exploring non-reciprocal superconductivity through Josephson junction dynamics*" and, if selected, will be carried by Dr. Heng Wu jointly between our two labs (Ali Lab and Steele Lab).

Creating and controlling non-reciprocal superconducting devices, in analogy to semiconducting devices, has long be sought after. Only very recently has the opportunity emerged due to progress in creating novel 2D Josephson junctions (JJ - two superconductors weakly connected by a non-superconducting barrier) using layered quantum materials as the barrier. Understanding and utilizing novel quantum materials and quantum phenomena is part of the Kavli institute's mission and this opportunity can fully flourish by joining the specialized expertise of our groups. Our long-term goal is to exploit these novel JJs to create ultra-fast and ultra-low power switching devices for THz computing. Using the KIND Seed funding we propose to take the first step and create on-chip, non-reciprocal Josephson junctions using Ali lab quantum materials and 2D device fabrication, and probe their dynamical response to high frequency excitations using Steele lab superconducting circuit design and measurement abilities. This project utilizes the our complimentary expertise and strengthens synergy in KIND between material science and device physics, opening the door to many new future explorations.

Trying to create new, Thz computing devices based of very recent (2020/2021) progress in non-reciprocal superconductivity is very risky, and the Kavli Seed money would provide a unique opportunity and resource for us to collaborate and see if this is feasible. It would also provide a bridge for Dr. Wu to transition from fundamental research into applied research (as is his goal) by jointly working between the Ali and Steele labs on this project. If successful, the project could yield exciting preliminary results that would form the foundation of a larger scale future proposal.

Sincerely,

Profs. Mazhar Ali and Gary Steele

Department of Quantum Nanoscience
Kavli Institute of Nanoscience
Faculty of Applied Sciences
Delft University of Technology (**TU Delft**)
M.N.Ali@tudelft.nl
+310628280964
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+310152783402

Attached: Research proposal, requested budget with justification, and full CV's of applicants and postdoctoral candidate.

Project Proposal

Section 1: Applicants

- **Prof. dr. M. N. Ali** and **Prof. dr. G. A. Steele**
- Three most relevant recent publications of **Prof. Ali**:
    - *Realization of the field-free Josephson diode*, Wu, H., Wang, Y., Sivakumar, P., Pasco, C., Parkin, S. Zeng, Y. J., McQueen, T., **Ali, M. N.**, accepted at Nature (2022)
    - *Proximity-induced spin-triplet superconductivity and edge supercurrent in the topological Kagome metal, KV_3Sb_5*, Wang, Y., Yang, S. Y., Ortiz, B., Garg., C., Wu, H., **Ali, M. N.**, under review at *Nature Physics* (2022)
    - *Evidence of higher-order topology in multilayer WTe_2 from Josephson coupling through anisotropic hinge states*, Choi, Y. B., Xie, Y., Chen, C. Z.,…, Fong, K. C*., **Ali, M. N.***, Law, K. T.*, Lee, G. H.*, *Nature Materials*, 19, 974 (2020)
- Three most relevant recent publications of **Prof. Steele**:
    - *Photon-Pressure Strong-Coupling between two Superconducting Circuits*, D. Bothner, I.C. Rodrigues, **G. A. Steele**, *Nature Physics* 17, 85 (2021)
    - *Observation and stabilization of photonic Fock states in a hot radio-frequency resonator*, Mario F. Gely, Marios Kounalakis, Christian Dickel, Jacob Dalle, Rémy Vatré, Brian Baker, Mark D. Jenkins, **Gary A. Steele**, *Science 363, 1072 (2019)*
    - *A ballistic graphene superconducting microwave circuit*, Felix E. Schmidt, Mark D. Jenkins, Kenji Watanabe, Takashi Taniguchi, **Gary A. Steele**, *Nature Communications* 9, 4069 (2018)
- Postdoctoral Candidate: **Dr. Heng Wu's** three most relevant recent publications:
    - *Realization of the field-free Josephson diode*, **Wu, H.**, Wang, Y., Sivakumar, P., Pasco, C., Parkin, S. Zeng, Y. J., McQueen, T., Ali, M. N., accepted at Nature (2022)
    - *Proximity-induced spin-triplet superconductivity and edge supercurrent in the topological Kagome metal, KV_3Sb_5*, Wang, Y., Yang, S. Y., Ortiz, B., Garg., C., **Wu, H.**, Ali, M. N., under review at *Nature Physics* (2022)
    - *Structural, magnetic, dielectric and optical properties of double-perovskite Bi_2FeCrO_6 ceramics synthesized under high pressure*, **Heng Wu**, Z. Pei, W. Xia, Y. Lu, K. Leng, X. Zhu, *Journal of Alloys and Compounds*, 819 153007 (2020)

Section 2: Title of the Project

Exploring non-reciprocal superconductivity through Josephson junction dynamics

Section 3: Names of the Kavli faculty members that will support the project (name, affiliation, and web pages)

- Prof. M. N. Ali, Department of Quantum Nanoscience, *website in development*
- Prof. G. Steele, Department of Quantum Nanoscience, https://steelelab.tudelft.nl/

Section 4: Abstract

Non-reciprocal superconductivity has only very recently been observed in symmetry breaking intrinsic superconductors and now in 2D quantum material Josephson junctions (termed Josephson diodes). In Josephson diodes, superconducting diodic behavior with very high rectification was shown *without* applied magnetic fields. While multiple possible driving mechanisms have been suggested, at present no consensus has been reached. Also, the use of non-reciprocal superconductivity has been proposed for high speed electronics, but no experiment has broached this. Here we propose to use the KIND seed money and combine the expertise of the Ali lab in quantum material synthesis and device fabrication with the Steele lab expertise in superconducting circuits and high frequency measurements to fabricate RF compatible Josephson diodes. We will study the dynamics of the superconducting diode effect for the first time, to probe both the mechanism as well as the potential for technological application in high speed electronics, including THz computing.

Section 5: Benefit to the synergy of KIND

Exploring, understanding, and utilizing novel quantum materials and quantum phenomena is strongly related to the Kavli institute's mission. Creating Josephson diodes using quantum materials and studying their dynamics using high frequency measurements, embodies those goals and strengthens the synergy of KIND by allowing us to combine the complimentary expertise of our groups and enabling us to work together. The project probes both fundamental physics in exploring the origin of the effect as well as the potential for future technological application in important sectors like superconducting electronics and THz computing. The cross-pollination of knowledge and ideas from this project will benefit future collaborations in KIND between material science and

device physics and will pave the way for exploring emergent physics arising from the mixture of superconductivity with the various types of intrinsic properties of quantum materials.

Section 6: Research Proposal

Background and state of the art: Nonreciprocal transport is incredibly important in technology; for example, asymmetry in the current-voltage response in semiconductor junctions has been the cornerstone of computing technology for half a century. However nonreciprocal superconductivity proved elusive, and only in 2020 was the superconducting diode effect (superconducting in one direction while normal conducting in the other) discovered for the first time in an alloy of V/Nb/Ta[1] by breaking both inversion and time reversal symmetry (using an applied magnetic field). Earlier this year, a Josephson diode (JD) was created in a quantum material Josephson junction (QMJJ, a junction made up of two superconductors separated by a non-superconducting barrier comprised of a quantum material)[2]. Here a diodic effect was seen *without* an applied magnetic field; a puzzling result for theoretical physicists but an important advance for technological application, making them amenable to high density on-chip operation. Josephson junction based computing was heavily investigated in the 1970-80s due to intrinsically ultra-high switching speeds on the order of THz and ultra-low power dissipation (μW), but was eventually abandoned partially due to error and control issues stemming from the lack of nonreciprocal superconductivity[3], which the Josephson diode inherently addresses. While there have been some recent theoretical suggestions for explaining the Josephson diode, no consensus has been reached on the underlying mechanism and no studies have yet explored their dynamics.

Aim of the project: Here we propose to fabricate Josephson diodes using layered quantum materials sandwiched between layered superconductors on-chip and probe their dynamical response to high frequency excitations. This will allow us to make both fundamental and technological progress by probing the origin of the effect as well as its potential for high speed computing applications. It was suggested that JDs function due to creation of an electric dipole (analogous to a p-n junction) possibly from the interface of the quantum material with the layered superconductor. The proposed frequency dependent switching measurements will shed light on this and also may enable more than one route to realizing and tuning nonreciprocal superconducting devices.

Approach: The strategy is two fold: first Josephson diodes in the form of vertical QMJJs will be created through 2D heterostructure fabrication by exfoliating and stacking of layered quantum materials and superconductors (Figure 1 left and middle). In particular, Nb_3Cl_8 and Nb_3Br_8, will be utilized as the quantum material as these were the first materials to be used in Josephson diodes and have been predicted to host polarized top and bottom surface states and, correspondingly, a net electric dipole. Additionally, other materials including $CuInP_2S_6$ (a layered 2D ferroelectric with out-of-plane polarization[4]) will be similarly investigated. Next, variable AC frequency current excitations up to several 10's of GHz will be applied and the frequency dependent response observed (Figure 1 right shows the only dynamical measurement to date, at a paltry 0.1Hz). Varying device geometries, layer thickness, and material choices will be tested to optimize the diode effect to as and lay the groundwork for future superconducting circuits (including logic) utilizing the Josephson diode.

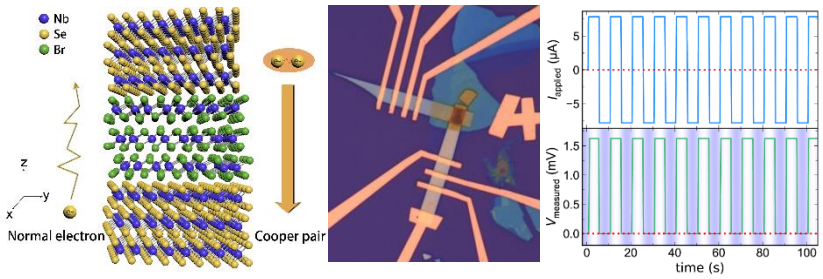


Figure 1. left: schematic of Josephson diode heterostructure. Middle: example of hBN capped device (dark center) w/gold contacts. Right: rectification of a square wave excitation.

Candidate: Dr. Heng Wu – Dr. Wu is well suited to this project as he has multiple areas of expertise including 2D material heterostructure fabrication and DC and AC measurement and analysis. He created the first Josephson diode and originated this field of research. He is extraordinarily creative and a very fast learner who now aims to gain expertise in high frequency measurements on his path to an R1 professorship in applied physics. The proposed project fits his goal of transitioning to more applied research, including broader measurement techniques, as Josephson diodes may serve as the basis for the long sought after superconducting THz computer. He will begin working on this project immediately, if funding is granted.

Ref. 1: F. Ando et al., Nature, 584, 373, 2020
Ref. 2: H. Wu et al., arXiv:2103.15809
Ref. 3: K. K. Likharev and V. K. Semenov, IEEE Transactions on Applied Superconductivity, 1, 1, 1991
Ref. 4: F. Liu et al., Nature Communications, 7, 12357, 2016

IV: Requested budget and brief justification

The requested budget of 50kEuro will be primarily invested in the postdoc position of 6 months for Dr. Wu with the remaining part for publications and travel. The equipment for the project is already present in our labs and consumable costs will be incorporated into existing budgets.

Mazhar N. Ali **(Born US Citizen)**

Associate Professor Delft University of Technology
Email: M.N.Ali@tudelft.nl USA Phone: +19252864907 NL Phone: +310628280964
Website: https://www.mpi-halle.mpg.de/ali,
Google Scholar: https://scholar.google.com/citations?user=QZOYaB4AAAAJ&hl=en
Houthaak 28, 2611 LE, Delft, Netherlands

QUALIFICATIONS:

- Diverse research and development expertise in both industry and academia (condensed matter physics, solid state chemistry, materials science, device electronics, nuclear chemistry, water engineering, dark matter detection) with a strong publishing track record in high-impact journals (50+ articles, 6000+ citations).
- Successful experience in technical start-up companies, particularly related to water intelligence and materials informatics.

EDUCATION:

- **PhD** in **Chemistry and Materials** – Princeton University, January 2015
- **M. Sc.** in **Chemistry** – Princeton University, October 2011
- **B.A.** in **Physics** – University of California, Berkeley, May 2009
- **B.A.** in **Chemistry** – University of California, Berkeley, May 2009

PROFESSIONAL EXPERIENCE:

08/2021 – Present	Delft University of Technology (TU Delft) - Associate Professor
10/2018 – Present	Material Mind Inc. – Co-founder and Chief Scientific Officer
06/2019 – Present	*Science Advances* – Associate Editor
11/2016 – 07/2021	MPI-Microstructure Physics - Humboldt Sofia Kovalevskaja Group Leader (PI)
04/2016 – 07/2018	Ketos Inc. – Chief Scientist
02/2015 – 09/2016	IBM Almaden Research Center – Postdoctoral Research Associate
07/2010 – 12/2014	Princeton University – Graduate Student and Teaching Assistant
10/2012 – 10/2014	Physics and Chemistry Private Tutor
01/2007 – 05/2010	University of California, Berkeley – Undergraduate Research Assistant
01/2006 – 06/2006	Clorox Services – Research Intern
06/2005 – 08/2005	Bayer Biological Products – Research Intern
01/2005 – 05/2005	University of California, Berkeley - Cal Leadership Symposium Organizer
12/2004-05/2005	Diablo Valley College – Chemical Preparation Worker
06/2002-08/2002	John Muir Medical Center – Biomedical Engineering Assistant
01/2000-01/2002	Books for the Barrios, Inc. – Assistant Director of Technical Operations

AWARDS and FUNDING:

- **2016 Minerva ARCHES Prize** sponsored by the German Ministry for Education and Research (BMBF) – *200,000 Euro Award* given to two PI's in Germany and Israel.
- **2016 Sofia Kovalevskaja Award** sponsored by the Alexander von Humboldt Foundation – 6 winners chosen in an *international competition* open to all countries and scientific fields. ***Awarded the maximum (1.65 Million Euro) amount***.
- Obtained **Seed venture capital funding** (08/2017) for my company, Ketos Inc.; *2.4 Million USD* at 10 Million USD valuation.
- Obtained **Series A venture capital funding** (03/2019) for my company, Ketos Inc.; *7 Million USD* at 35 Million USD valuation.
- Selected as **Journal of Physics: Condensed Matter's *Emerging Leader 2019*** – JPCM's editorial board puts together an annual list of top researchers from all areas of condensed matter

physics *deemed as the most exciting researchers of their generation, with the potential to revolutionize their fields*.

PROFESSIONAL ACTIVITIES:

2019	Member of the American Association for the Advancement of Science (AAAS)
2018	Co-Founded Material Mind Inc., my AI-based materials intelligence company, Fremont, CA
2017	Built my independent research group at the Max Plank Institute for Microstructure Physics
2017	Built R&D/Product Dev. divisions at Ketos Inc., San Jose, CA
2017	Won 1st place, World Open Innovation Conference, Start-Up Disruption Category
2017	Selected for Phase II of UC Berkeley's "Smart Village" Program
2017	Chapter author for book, *Symmetry (Group Theory) and Mathematical Treatment in Chemistry*
2016	Organized SPICE Young Research Leaders Workshop: New Paradigms in Dirac and Weyl Nanoelectronics
2014	Treasurer – Princeton Students for Human Rights in China (PSHRC)
2014	Vice President – Materials Scientists Engaged in Teaching and Learning (METAL)
2010	Member of the American Physical Society (APS)
2010	Member of the American Chemical Society (ACS)
2005	Organized the 2005 Cal Leadership Symposium at UC Berkeley.
Ongoing	Reviewer: *Nature Physics, Nature Communications, Science Advances, Advanced Materials, Advanced Functional Materials, Nature Scientific Reports, Nature Physics, Nature Materials, Nature Reviews Materials, Advances in Physics, ACS Applied Materials and Interfaces, APEX, J. Crys. Growth and Design, J. Solid State Chem., Nanoscale, PSS, PRL, JMMM, PNAS*

TECHNICAL EXPERTISE:

Thin Film Growth and Device Fabrication: Sputtering, Molecular Beam Epitaxy, Pulsed Laser Deposition, Polymer Assisted Deposition, Chemical Vapor Deposition. Exfoliation, E-beam and Photolithography.

Bulk Material Synthesis: Arc melting, Induction furnace techniques, high pressure synthesis, liquid chemical intercalation, Bridgman growth, chemical vapor transport, flux techniques, solid state techniques.

Material Characterization: Powder x-ray, Single Crystal x-ray, Synchrotron and Neutron Diffraction. Electrical transport, Kerr Microscopy, FMR, SQUID, SEM, TEM, EDS, XPS, and AFM. Ionic liquid, back and top gating, pressurized transport, exfoliation, and layer-by-layer heterostructure fabrication.

ADVISEES:

PostDocs: Yaojia Wang (Max Plank Institute for Microstructure Physics, Halle '21), Mohsin Minhas (MPI-Halle '21), Heng Wu (MPI-Halle '21)

Graduate Students: Chirag Garg (PhD Physics, Martin Luther University, Halle, '19), Elisa Yang (PhD Physics, Max Plank Institute for Microstructure Physics, Halle '20), Jiho Yoon (PhD student in Physics, MPI-Halle expected '21), Elena Derunova (PhD student in Physics, MPI-Halle '21)

Undergraduate Students: Cindi Yim (B.S. Chemistry, Princeton, '13), Steven Flynn (B.S. Chemistry, Princeton, '14), Madison Mastern (B.S. Physics and Computer Science, Santa Clara University, '18)

NEWS/PRESS:

1.) "When Dirac meets frustrated magnetism" - https://phys.org/news/2020-07-dirac-frustrated-magnetism.html - story went viral on many, many science and general interest websites.
2.) "Bizarre, never-before-seen material could drive the next-gen of computers" - https://www.inverse.com/innovation/next-gen-computer-materials

3.) "Higher-order topology found in 2-D crystal" - https://phys.org/news/2020-07-higher-order-topology-d-crystal.html
4.) "'Butterfly' magnetoresistance seen in nonmagnetic Dirac material" - https://www.nanotec.or.th/en/?p=10477
5.) "Unstoppable Magnetoresistance" - https://phys.org/news/2014-10-unstoppable-magnetoresistance.html
6.) "Sofja Kovalevskaja Award for Dr. Mazhar Ali" - https://www.mpi-halle.mpg.de/177301/sofja-kovalevskaja-award

PATENTS:

1.) **Ali**, **M. N.,** Sankaran, M. (2017): Non-Contact Fluid Level Sensor. Santa Clara, USA 11-30-2017

2.) **Ali**, **M. N.,** Sankaran, M. (2016): Automated Smart Water Quality Monitor and Analyzer and Associated Methods. Serial # 15/649379, Santa Clara, USA 07-13-2017

3.) **Ali, M. N.,** Sankaran, M. (2017): Self-Charging Water Usage Monitor, Systems, and Methods. Serial # PCT/US2017/034043, Santa Clara, USA, 05-23-17

4.) **Ali**, **M. N.,** Cava, R. J., Ali, Z. (2014): Uses of the Titanic Magneto-Resistance (XMR) in WTe_2 and devices based on the effect as well as an advanced synthesis method for making high quality WTe_2 samples and controlling the XMR Effect. Invention# 15-3071-1, Sept. 24, 2014 (http://puotl.technologypublisher.com/technology/19977)

5.) **Ali**, **M. N.,** Garlund, E., Nitsche, H. (2008): Radspin - A self-contained spin coating instrument designed to accommodate radioactive and otherwise precious or hazardous solutions. LBNL, Berkeley, CA, 2008

Complete list of scientific presentations of Mazhar N. Ali

PRESENTATIONS (**33 Invited Talks**):

1.) **Mazhar N. Ali**, et al, "Realization of the field-free Josephson diode", Virtual Science Forum Seminar, May 5th, 2021 (**Invited talk**)

2.) **Mazhar N. Ali,** et al, "From Silicon Valley to Dark Matter: discovering and utilizing quantum materials and effects", NTU Condensed Matter Seminar, March 3rd, 2021 (**Invited talk**)

3.) **Mazhar N. Ali**, et al, "Combining Old and New Ideas to put a Spin on Superconductivity", Alexander von Humboldt Virtual Network Meeting, Halle, Germany, Nov. 18th, 2020 **(Keynote Lecture)**

4.) **Mazhar N. Ali**, et al, "From unconventional anomalous Hall effects to axion insulators: unexpected properties and uses of quantum materials", University of California at Los Angeles, Los Angeles, USA, Mar. 4th, 2020 **(Invited talk)**

5.) **Mazhar N. Ali**, et al, "From Spintronics to Dark Matter: understanding and using electronic structure information for materials applications", Santa Clara University, Santa Clara, USA, Feb. 25th, 2020 **(Invited talk)**

6.) **Mazhar N. Ali**, et al, "Linking Symmetry, Crystal Chemistry, Electronic Structure, and Properties, Parts I and II", *Quantum Materials Workshop Lecture*, Cambridge Unversity, England, Dec. 7th, 2019 **(Invited talk)**

7.) **Mazhar N. Ali**, et al, "Novel concepts and discoveries with the spin and anomalous Hall effects: Prediction to experiment", *Quantum Materials Workshop*, Cambridge University, England, Dec. 6th, 2019 **(Invited talk)**

8.) **Mazhar N. Ali**, et al, "Deriving Descriptors from Fundamental Physics for Predicting Material Properties using AI", *Machine Learning for Quantum Matter*, NORDITA, Stockholm, Sweden, August 26th, 2019 (talk)

9.) **Mazhar N. Ali**, et al, "Spin Hall Effect and Fermi Surface Hyperbolicity", *Gordon Research Conference: Topological and Correlated Matter*, Hong Kong University of Science and Technology, Hong Kong, June 17th, 2019 (Poster)

10.) E. Derunova, **Mazhar N. Ali**, et al, "Prediction of Hall effects from geometrical properties of the Fermi Surface", *APS March Meeting*, Boston, USA, March 4th, 2019 (talk given for E. Derunova)

11.) **Mazhar N. Ali**, et al, "A Proposal to Detect Dark Matter using Axionic Topological Antiferromagnets", *APS March Meeting*, Boston, USA, March 4th, 2019 (talk)

12.) **Mazhar N. Ali**, et al, "Linking Symmetry, Crystal Chemistry, Electronic Structure, and Properties Part II", *IMPRS-STNS Lecture*, Max Plank Institute for Microstructure Physics, Halle, Germany, Dec 19th, 2018 **(Invited talk)**

13.) **Mazhar N. Ali**, et al, "Linking Symmetry, Crystal Chemistry, Electronic Structure, and Properties", *IMPRS-STNS Lecture*, Max Plank Institute for Microstructure Physics, Halle, Germany, Nov 28th, 2018 **(Invited talk)**

14.)**Mazhar N. Ali**, et al, "2 years with Sofia Kovalevskaja – From dark matter to the spin Hall effect" *Alexander von Humboldt Foundation's Sofia Kovalevskaja Award Ceremony*, Berlin, Germany, Nov 22nd, 2018 **(Invited talk)**

15.)**Mazhar N. Ali**, et al, "Using Topology: From Detecting Dark matter to making a Giant spin hall effect", *SSPCM Summer School*, Rzeszow, Poland, Sept 12th, 2018 **(Invited talk)**

16.)**Mazhar N. Ali**, et al, "Using ideas from topology; aiming for the spin hall effect and dark matter", Raytheon-BBN, Boston, Mass. USA, July 27th, 2018 (I**nvited talk)**

17.)**Mazhar N. Ali**, et al, "Intrinsic Spin Hall Effect in the A15 Structure Type", *Gordon Research Conference: Solid State Chemistry*, Colby-Sawyer College, USA, 2018 (poster)

18.)**Mazhar N. Ali**, et al, "Chasing the QCD Axion using Topological Antiferromagnets", *NORDITA: Topological Matter and Beyond the Ten-Fold Way*, Stockholm, Sweden, July 18th, 2018 **(Invited talk)**

19.)**Mazhar N. Ali**, et al, "Spin Hall, Berry Curvature and Dirac-like materials", *APS March Meeting*, Los Angeles, CA, March 7th, 2018 (talk)

20.)**Mazhar N. Ali**, et al, "Spin Hall, Berry Curvature and Dirac-like materials and the Intrinsic Asymmetric Josephson Effect", *SFB 762 Proposal Workshop*, Frauenworth Chiemsee, Germany, Feb. 27th, 2018 (**Invited Talk**)

21.)**Mazhar N. Ali**, et al, "Spin Hall, Berry Curvature and Dirac-like materials", *Relativistic Fermions and Nodal Semimetals Workshop*, Banff International Research Station, Banff, Canada, Feb. 13th, 2018 (**Invited Talk**)

22.)**Mazhar N. Ali**, et al, "Symmetry, Topology, and the Spin Hall effect in real materials", Karlsruhe Institute of Technology, Karlsruhe, Germany, Nov. 28th, 2017 (**Invited Talk**)

23.)**Mazhar N. Ali**, et al, "Spin Hall, Berry Curvature, and Dirac-like Materials", *Quantum Materials Symposium*, Berlin, Germany, Oct. 5th, 2017 (**Invited Talk**)

24.)**Mazhar N. Ali**, et al, "Spin Hall, Berry Curvature, and Dirac-like Materials", *Topological Semimetals and Beyond*, Weizmann Institute, Israel, Sept. 14th, 2017 (**Invited Talk**)

25.)**Mazhar N. Ali**, et al, "Intrinsic Spin Hall Effect in the A15 Structure Type", *Gordon Research Conference, Spin Dynamics in Nanostructures*, Les Disabrelets, Switzerland, July 17th, 2017 (Poster)

26.)**Mazhar N. Ali**, et al, "Intrinsic Spin Hall Effect in the A15 Structure Type", *SPICE Spin Dynamics in Dirac Systems*, Mainz, Germany, June 6th, 2017 (Poster)

27.)**Mazhar N. Ali**, et al, "Optimizing the intrinsic spin Hall effect in Materials (while finding new topological materials): A design strategy", *Weizmann meets MPG Workshop*, Dresden, Germany, June 5th, 2017 (**Invited Talk**)

28.)**Mazhar N. Ali**, et al, "Dirac and Weyl Materials; a Chemist's Approach to Exotic Physics", Martin Luther University, Halle, Germany, April 20th, 2017 (**Invited Talk**)

29.)**Mazhar N. Ali**, et al, "Thin Films of Novel Fermion Material, Ta_3Sb", *APS March Meeting*, New Orleans, USA, March 15th, 2017 (Talk)

30.)**Mazhar N. Ali**, et al, "A chemist's approach to maximizing the spin Hall effect", *Chemistry meets Physics of Solids Workshop*, Ringberg, Germany, Feb 3rd, 2017 (**Invited Talk**)

31.)**Mazhar N. Ali**, et al, "Dirac and Weyl Physics and Applications: A Chemists Point of View", University of Texas, Dallas, USA, Dec. 15th, 2016 (**Invited Talk**)

32.)**Mazhar N. Ali**, et al, "Towards Novel Dirac/Weyl Devices and Applications", *BEYOND! Workshop*, Ringberg, Germany, 11th, 2016 (**Invited Talk**)

33.)**Mazhar N. Ali**, et al, "Towards "New Fermions": Dirac and Weyl Physics with Sofja Kovalevskaja", *Alexander von Humboldt, Sofia Kovalevskaja Award Ceremony*, Berlin, Germany, Nov. 15th, 2016 (**Invited Talk**)

34.)**Mazhar N. Ali**, et al, "Materials Engineering: A Chemist's Perspective", Max Plank Institute for Microstructure Physics NISE Retreat, Meisdorf, Germany, Nov. 3rd, 2016 (**Invited Talk**)

35.)**Mazhar N. Ali**, et al, "Butterfly Magnetoresistance and a Topological Phase Transition in ZrSiS" *Gordon Research Conference: Solid State Chemistry*, Colby-Sawyer College, USA, July 18-19, 2016 (poster)

36.)**Mazhar N. Ali**, et al, "Beyond MR and Mobility; A Possible Vision for Dirac/Weyl Devices", *SPICE Center, Johannes von Gutenberg University*, Mainz, Germany, June 13th, 2016 (**Invited Talk**)

37.)**Mazhar N. Ali**, "Titanic (and Butterfly) Magnetoresistance in Dirac/Weyl semimetals" *MRS March Meeting*, Phoenix, March 30, 2016 (talk)

38.)**Mazhar N. Ali**, "Peculiar Angular Magnetoresistance in New Dirac Semimetal, ZrSiS" *APS March Meeting*, Baltimore, March 14, 2016 (talk)

39.)**Mazhar N. Ali**, "Dirac and Weyl Semimetals; a Chemist's Approach" University of California, Santa Barbara, Public Talk at Faculty Interview, March 07, 2016

40.)**Mazhar N. Ali**, et al, "Dirac and Weyl Semimetals: A Chemists Approach" Santa Clara University, Santa Clara, USA, October 26h, 2015 (**Invited Talk**)

41.)**Mazhar N. Ali**, et al, "Dirac and Weyl Semimetals: A Chemists Approach" Harvard, Cambridge, USA, October 16th, 2015 (**Invited Talk**)

42.)**Mazhar N. Ali**, et al, "New Insights into the Titanic Magnetoresistance of WTe_2" MPI for Solid State Research, Stuttgart, Germany, July 15th, 2015 (**Invited Talk**)

43.)**Mazhar N. Ali**, et al, "Mammoth Spin Hall Angle in Thin Films of the Weyl Semimetal, WTe_2" *ICNS: Advances in Nanoscience Applications, Cambridge, UK*, July 12th, 2015 (poster)

44.)**Mazhar N. Ali**, et al, "The Crystal and Electronic Structure of Cd_3As_2: a 3D analog to Graphene" *Gordon Research Conference: Topological and Correlated Matter*, Hong University of Science and Technology, Hong Kong, China, June 29th, 2015 (poster)

45.)**Mazhar N. Ali**, et al, "Titanic Magnetoresistance in WTe_2" *Chemistry meets Physics Workshop, Ringberg Castle, Ringberg, Germany*, March 19th, 2015 (poster)

46.)**Mazhar N. Ali**, "Large, Non-saturating Magnetoresistance in WTe_2" *APS March Meeting,* San Antonio, March 3rd, 2015 (talk)

47.)**Mazhar N. Ali**, "Ballistic Electrons and Perfect Carrier Balance in Cd_3As_2 and WTe_2", IBM Almaden Research Center, USA, February 1st, 2015 (**Invited Talk**)

48.)**Mazhar N. Ali**, "Ballistic Electrons and Perfect Carrier Balance in Cd_3As_2 and WTe_2" *MPI für Chemische Physik fester Stoffe* , Dresden, Germany, Sept 15th, 2014 (**Invited Talk**)

49.)**Mazhar N. Ali**, et al, "Titanic Magnetoresistance in WTe_2" *Gordon Research Conference: Solid State Chemistry*, Colby-Sawyer College, USA, July 28-29th, 2014 (poster)

50.)**Mazhar N. Ali,** "Materials Engineering: A Solid State Chemist's Perspective", *Princeton Review of Innovation in Science and Engineering (PRISE)*, Princeton University, February 28, 2013. (**Invited Talk**)

51.)**Mazhar N. Ali**, "$Na_3Cu_2Ru_2O_8$: Das Discombobulating Defect α-$NaFeO_2$ Derivative", *Mainz Solid State Chemistry Workshop*, Johannes von Gutenberg University, Mainz, Germany, June 15, 2012 (**Invited Talk**)

52.)**Mazhar N. Ali** et al., "Metal oxide films produced by Polymer-Assisted Deposition (PAD) for nuclear science applications" *2008 Annual Meeting of the Division of Nuclear Physics, American Physical Society*, Oakland, CA, October 23-26, 2008. (poster)

53.)**M. N. Ali**, N. N. Chang, M. A. Garcia, H. Nitsche, "Incorporating social networking tools to facilitate participation and discussion in nuclear chemistry", *235th American Chemical Society National Meeting,* New Orleans, Louisiana, April 6-10, 2008 (talk)

Complete list of publications of Mazhar Nawaz Ali

Thesis:

Ali, M. N. (2015): Extraordinary electronic properties in uncommon structure types. Princeton University Printing Press, Princeton, Doctoral Dissertation, 121pp.

Publications (Total Citations: 5936, h-index: 28, i10-index: 43):

A) Publications with peer review process

1.) Markou, A., Gayles, J., Derunova, E., Swekis, P., Noky, J., Zhang, L., **Ali, M. N.**, Sun, Y., Felser, C. (2021): Hard magnet topological semimetals in XPt_3 compounds with the harmony of Berry curvature. *Communications Physics*, 4, 1, 1-7.

2.) Wang,. Y, Lee, G. H., **Ali, M. N.** (2021): Topology and superconductivity on the edge. *Nature Physics* 17, 5, 542 - 546.

3.) Yang, S.Y., Noky, J., Gayles, J., Dejene, F.K., Sun, Y., Dorr, M., Skourski, Y., Felser, C., **Ali, M. N.**, Liu, E., Parkin, S. S. P. (2020): Field-Modulated Anomalous Hall Conductivity and Planar Hall Effect in $Co_3Sn_2S_2$ Nanoflakes. *Nano Letters*, 20 (11), 7860

4.) Minhas, M. Z., Pandeya, A. K., Grover, B., Fumarola, A., Kostanovskiy, I., Hoppe, W., Woltersdorf, G., Bedoya-Pinto, A., Parkin, S. S. P., **Ali, M. N.** (2020): Doping-induced spin Hall ratio enhancement in A15-phase, Ta-doped Beta-W thin films. *Journal of Physics: Materials*, 3, 4.

5.) Choi, Y. B., Xie, Y., Chen, C. Z., Park, J., Song, S.B., Yoon, J., Kim, B. J., Taniguchi, T., Watanabe, K., Kim, J., Fong, K. C., **Ali, M. N.**, Law, K. T., Lee, G. H. (2020): Evidence of higher-order topology in multilayer WTe_2 from Josephson coupling through anisotropic hinge states. *Nature Materials*, 19, 974.

6.) Yang, S.Y., Wang, Y., Ortiz, B., Liu, D., Gayles, J., Derunova, E., Gonzalez-Hernandez, G., Smejkal, L., Chen, Y., Parkin, S. S. P., Wilson, S., Toberer, E., McQueen, T., **Ali, M. N.** (2020): Giant, unconventional anomalous Hall effect in the metallic frustrated magnet candidate, KV_3Sb_5. *Science Advances*, 6, 31, eabb6003. Impact Factor: 13.1

7.) Yoon, J., Lesne, E., Sklarek, K., Sheckelton, J., Pasco, C., Parkin, S. S. P., McQueen, T. M., **Ali, M. N.** (2020): Anomalous thickness-dependent electrical conductivity in van der Waals layered transition metal halide, Nb_3Cl_8. *Journal of Physics: Condensed Matter*, 32, 30, 304004.

8.) Marsh, D.J.E., Fong, K.C., Lentz, E.W., Smejkal, L., **Ali, M. N.** (2019): Proposal to Detect Dark Matter Using Axionic Topological Antiferromagnets. *Physical Review Letters*, 123, 12, 121601.

9.) Borisenko, S., Evtushinsky, D., Gibson, Q., Yaresko, A., Koepernik, K., Kim, T., **Ali, M. N.**, Brink, J., Hoesch, M., Fedorov, A., Haubold, E., Kushnirenko, Y., Soldatov, I., Schafer, R., Cava, R.J. (2019): Time-reversal symmetry breaking type-II Weyl state in $YbMnBi_2$. *Nature Communications*, 10, 1, Impact Factor: 12.1

10.) Derunova, E., Sun, Y., Felser, C., Parkin, SSP., Yan, B., **Ali, M. N.** (2019): Giant spin Hall effect in W_3Ta and other A15 Superconductors. *Science Advances 5 (4), eaav8575*

11.) Weber, C. P., Schoop, L., Parking, S. S. P., Newby, R. C., Nateprov, A., Lotsch, B., Mariserla, B. M. K., Kim, M. J., Dani, K. M., Bechtel, H. A., Arushanov, E., **Ali, M. N.** (2018): Directly photoexcited Dirac and Weyl fermions in ZrSiS and NbAs. *Applied Physics Letters, 113, 221906*. Impact Factor: 3.5

12.) Chen, C. Z., Jun He, J., **Ali, M. N.**, Lee, G. H., Fong, K. C., Law, K. T. (2018): Asymmetric Josephson Effect in Inversion Symmetry Breaking Topological Materials. *Phys. Rev. B.*, 98, 075430 Impact Factor: 3.84

13.) Yang, S. Y., Yang, H., Derunova, E., Parkin, SSP, Yan, B., **Ali, M. N.** (2018): Symmetry Demanded Topological Nodal-line Materials. *Advances in Physics X, 3 (1), 1414631*.

14.) Weber, C. P., Berggren, B. S., Masten, M.G., Ogloza, T.C., Deckoff-Jones, S., Madeo, J., Man, M. K. L., Dani, K. M., Zhao, L., Chen, G., Liu, J., Mao, Z., Schoop, L. M., Lotsch, B., Parkin, SSP., **Ali, M. N.** (2017): Similar Ultrafast Dynamics of Several Dissimilar Dirac and Weyl Semimetals. *Editors Pick, Journal of Applied Physics*, 122, 223102. Impact Factor: 2.18

15.) **Ali, M. N.**, Schoop, L. M., Garg, C., Lippmann J. M., Lara, E., Lotsch, B. V., Parkin, S. S. P. (2016): Butterfly magnetoresistance, quasi-2D dirac fermi surfaces, and a topological phase transition in ZrSiS. *Science Advances*, 2 (12)

16.) Schoop, L. M., **Ali, M. N.**, Strasser, C., Duppel, V., Parkin, S. S. P., Lotsch, B. V., Ast, C. R. (2016): Dirac Cone Protected by Non-Symmorphic Symmetry and 3D Dirac Line Node in ZrSiS. *Nature Communications*, 7 (11696) Impact Factor: 11.47

17.) Das, P.K., Sante, D. D., Vobornik, I., Fujii, J., Okuda, T., Bruyer, E., Gyenis, A., Feldman, BE., Tao, J ., Ciancio, R., Rossi, G., **Ali, M.N.**, Picozzi, S., Yadzani, A., Panaccione, G., Cava R.J., (2016): Layer-dependent quantum cooperation of electron and hole states in the anomalous semimetal WTe_2. *Nature Communications*, 7.

18.) Holzmann, T., Schoop, L. M., **Ali, M. N.**, Moudrakovski, I., Gregori, G., Maier, J., Cava R.J., Lotsch, B. V., (2016): $Li_{0.6}[L_{i0.2}Sn_{0.8}S_2]$ – A Layered Lithium Superionic Conductor *Energy Environ. Sci.* (online) Impact Factor: 20.5

19.) Qi, Y., Naumov, P. G., **Ali, M. N.**, Rajamathi, C. R., Barkalov, O., Sun, Y., et al (2016): Superconductivity in Weyl Semimetal Candidate $MoTe_2$. *Nature Communications,* 7 (11038)

20.) Homes, C.C., **Ali**, **M. N.,** Cava, R. J. (2015): Optical properties of the perfectly compensated semimetal, WTe_2. *Physical Review B Rapid Communications*, 92, 16, 161109(R) Impact Factor: 5.1

21.) Sun, Y. Wu, S.C., **Ali, M. N.**, Felser, C. Yan, B. (2015): Prediction of a Weyl semimetal in orthorhombic $MoTe_2$. *Physical Review B Rapid Communications*, 92, 16, 161107(R)

22.) Schoop, L. M., Xie, L. S., Chen, R., Gibson, Q. D, Lapidus, S., Kimchi, I., Hirschberger, M. Haldolaarachchige, N., **Ali, M. N.**, Belvin, C. A., Liang, T., Neaton, J., Ong, NP, Vishwanath, A., Cava, RJ (2015): Dirac metal to topological metal transition at a structural phase change in Au_2Pb and prediction of Z_2 topology for the superconductor. *Physical Review B*, 91, 21, 214517

23.) **Ali**, **M. N.,** Schoop, L., Xiong, J., Flynn, S., Gibson, Q., Hirschberger, M., Ong, N. P., Cava, R. J. (2015): Correlation of crystal quality and Extreme Magnetoresistance of WTe_2. *Europhysics Letters: Editors Choice*, 110, 67002 Impact Factor: 2.1

24.) **Ali, M. N.**, Rohr, F., Campana, C., Schilling, A., Cava, R. J. (2015): The Crystal Structure, Electronic, and Magnetic Properties of $NaPd_3Ge_2$. *Materials Research Bulletin*, 70, 673-677 Impact Factor: 2.4

25.) Zhang, S., Wu, Q., Schoop, L., **Ali M. N.,** et al (2015): Breakdown of Three-dimensional Dirac Semimetal State in pressurized Cd_3As_2. *Physical Review B*, 91,(16) 165133

26.) Liang, T., Gibson, Q., **Ali, M. N.,** Liu, M., Cava, R. J., Ong, N. P. (2015): Ultrahigh Mobility and Giant Magnetoresistance in Cd_3As_2: Protection from backscattering in a Dirac semimetal. *Nature Materials*, 14 (3) 280-284 Impact Factor: 36.5

27.) Gibson, Q. D., Wu, H., Liang, T., **Ali**, **M. N.,** Ong, N. P., Cava, R. J. (2015): Magnetic and electronic properties of $CaMn_2Bi_2$: A possible hybridization gap semiconductor. *Physical Review B*, 91, 8, 085128

28.) Yankowitz, M., Larentis, S., Kim, K., Xue, J., McKenzie, D., Huang, S., Paggen, M., **M. N. Ali**, Cava, R. J., Tutuc, E., LeRoy, B. J. (2015): Intrinsic Disorder in grapheme on transition metal dichalcogenide heterostructures. *Nanoletters,* 15, 3, 1925-1929 Impact Factor: 13.6

29.) Pletikosic, I., **Ali, M. N.,** Fedorov, A., Cava, R. J., Valla, T. (2014): Electronic Structure Basis for the Extraordinary Magnetoresistance in WTe_2. *Physical Review Letters Editor's Suggestion*, 113, 216601 Impact Factor: 7.5

30.) Rowley, S.E., Hadjimichael, M., **Ali**, **M. N.,** Durmaz, Y. C., Lashley, J. C., Cava, R. J., Scott, J. F. (2014): Quantum Criticality in a uniaxial organic ferroelectric. *Accepted, Journal of Physics: Condensed Matter (2015).* Impact Factor: 2.3

31.) **Ali, M. N.,** Xiong, J., Flynn, S., Tao, J., Gibson, Q., Schoop, L., Liang, T., Haaldolaarachchige, N., Hirschberger, M., Ong, N. P., Cava, R. J. (2014). Large, non-saturating magnetoresistance in WTe_2. *Nature* 514 (7521) 205 Impact Factor: 41.6

32.) Seibel, E. M., Roudebush, J. H., **Ali**, **M. N.,** Ross, K. A., Cava, R. J. (2014): Structure and Magnetic Properties of the Spin-1/2 based honeycomb $NaNi_2BiO_{6-x}$ and its hydrate $NaNi_2BiO_{6-x}$*$1.7H_2O$. *Inorganic Chemistry,* 53, 20, 10989 Impact Factor: 4.8

33.) Gibson, Q. D., Evtushinsky, D., Yaresko, A. N., Zabolotnyy, V. B., **M. N. Ali**, et al (2014): Quasi one dimensional Dirac Electrons on the Surface of Ru_2Sn_3. *Scientific Reports*, 4, 5168 Impact Factor: 5.6

34.) Lashley, J. C., Munns, J. H. D., Echizen, M., **Ali, M. N.,** Rowely, S.E., Scott, J.F. (2014): Phase Transitions in the Brominated Ferroelectric Tris-Sarcosine Calcium Chloride. *Advanced Materials,* 26 (23) 3860-3866 Imapct Factor: 17.5

35.) **Ali**, **M. N.,** Gibson, Q., Jeon, S., Zhou, B. B, Yazdani, A., Cava, R.J. (2014): The Crystal and Electronic Structures of Cd_3As_2, the 3D electronic analogue of Graphene. *Inorganic chemistry* 53 (8), 4062-4067

36.) **Ali, M. N.,** Gibson, Q., Klimczuk, T., Cava, R. J. (2014): A Non-Centrosymmetric Superconductor with a Bulk 3D Dirac Cone Gapped by Strong Spin Orbit Coupling. *Physical Review B: Rapid Communications*, 89, 2, 020505

37.) Fuccillo, M.K., Gibson, Q. D., **Ali**, **M. N.,** Schoop, L. M., Cava, R. J. (2013): Correlated evolution of colossal thermoelectric effect and Kondo insulating behavior. *APL Materials*, 1 (6), 062102 Impact Factor: 4.3

38.) Seibel, E., Roudebush, J., Wu, H., Huang, Q., **Ali**, **M. N.,** Ji, H., Cava, R. J. (2013): Structure and Magnetic Properties of the α-$NaFeO_2$-Type Honeycomb Compound $Na_3Ni_2BiO_6$. *Inorganic Chemistry*, 52, 23, 13605

39.) Hirai, D., **Ali**, **M. N.,** Cava, R. J. (2013): Strong Electron-Phonon Coupling Superconductivity Induced by a low-lying Phonon in IrGe. *Journal of the Physical Society of Japan*, 82, 12 Impact Factor: 2.6

40.) Bocarsly, J.D., Hirai, D., **Ali, M. N.,** Cava, R. J. (2013): Superconducting phase diagram of In_xWO_3 synthesized by indium deintercalation. *Europhysics Letters*, 103, 1

41.) **Ali**, **M. N.,** Ji, H., Hirai, D., Fuccillo, M. K., Cava, R. J. (2013): Synthesis and Characterization of Two Crystallographic Forms of $Ag_{0.79}VS_2$. *J. Solid State Chem* 202, 77 Impact Factor: 2.1

42.) Schoop, L. M., Allred, J. M., Ni, N., Hirai, D., Krez, J., Schwall, M., Ji, H., **Ali**, **M. N.,** Cava, R. J. (2013): β-HfCuGe - A new polymorph of HfCuGe with a novel structure type. *Journal of Solid State Chemistry*, 199, 66

43.) Brenholm, M., Yim, C. K., Hirai, D., Climent-Pascual, E. , Xu, Q., Zangbergen, H. W., **Ali**, **M. N.,** Cava, R. J. (2012): Destabilization of the 6H-$SrIrO_3$ polymorph through partial substitution of zinc and lithium. *Journal of Materials Chemistry*, 22, 32, 16431 Impact Factor: 6.6

44.) **Ali, M.N.,** Garcia, M.A., Parsons-Moss, T. Nitsche, H. (2010): Nuclear Target Production: Homogenous Metal Oxide Films produced via the Polymer Assisted Deposition Method. *Nature Protocols* 5, 8, 1440 Impact Factor: 9.6

45.) Clark, R. M., Gregorich, K. E., Berryman, J. S., **Ali**, **M. N.,** et al (2010): High-K multi-quasiparticle states in ^{254}No. *Physics Letters B*, 690, 1, 19 Impact Factor: 0.7

46.) Garcia, M. A., **Ali, M. N.,** Chang, N. N., Parsons-Moss, T. Ashby, P. D., Gates, J. M., Stavsetra, L., Gregorich, K. E., Nitsche, H. (2010): Metal oxide targets produced by the polymer-assisted deposition method. *Nuclear Instruments and Methods in Physics Research Section A Proceedings of the 24th World Conference of the International Nuclear Target Development Society,* 613, 3, 396

47.) Jeppesen, H. B., Dragojevic, I., Clark, R. M., Gregorich, K. E., **Ali M. N.,** et al (2009): Multi-quasiparticle states in ^{256}Rf. *Physical Review C*, 79, 3, 031303 Impact Factor: 3.1

48.) Nelson, S. L., Gregorich, K. E., Dragojevic, I., Dvorak, J., Ellison, P. A., Garcia, M. A., Gates, J. M., Stavsetra, L., **Ali**, **M. N.,** Nitsche, H. (2009): Comparison of complementary reactions in the production of Mt. *Physical Review C*, 79, 2, 027605

49.) Gates, J. M., Stavsetra, L., Sudowe, R., **Ali**, **M. N.,** Calvert, M.G., Dragojevic, I., Dvorak, J., Dvorakova, Z., Ellison, P. A., Garcia, M. A., Gregorich, K. E. (2009):Extraction of niobium and tantalum isotopes using organophosphorus compounds. Part II – Extraction of "carrier-free" metal concentrations from HCl/LiCl solutions. *Radiochimica Acta*, 97, 3, 167 Impact Factor: 1.4

50.) Gates, J. M., Sudowe, R., Stavsetra, L., **Ali**, **M. N.,** Calvert, M. G., Dragojevic, I., Ellison, P. A., Garcia, M. A., Gharibyan, N., Gregorich, K. E., Nelson, S. L. (2009): Extraction of niobium and tantalum isotopes using organophosphorus compounds. Part I – Extraction of "carrier-free" metal concentrations from HCl solutions. *Radiochimica Acta*, 97, 3, 173

51.) Jeppesen, H. B., Clark, R. M., Gregorich, K. E., Afanasjev, A. V., **Ali M. N.,** et al (2009): High-K-multi-quasiparticle states and rotational bands in $_{103}^{255}$Lr. *Physical Review C*, 80, 3, 034324

52.) Garcia, M.A., **Ali, M.N**., Chang, N. N., Parsons-Moss, T., Ashby P. D., Gates, J. M., Stavsetra, L., Gregorich, K. E., Nitsche, H. (2008): Heavy-ion irradiation of thulium(III) oxide targets prepared by polymer-assisted deposition. *Nuclear Instruments and Methods A* 592, 483-485 Impact Factor: 1.2

53.) Garcia, M.A., **Ali, M.N**., Parsons-Moss, T., Ashby, P.D., Nitsche, H., (2008): Metal oxide films produced by polymer-assisted deposition (PAD) for nuclear science applications. *Thin Solid Films* 516, 6261-6265 Impact Factor: 1.9

B.) Submitted Publications with peer review process

1.) Wu, H., Wang, Y., Sivakumar, P., Pasco, C., Parkin, S. Zeng, Y. J., McQueen, T., **Ali, M. N.** (2021): Realization of the field-free Josephson diode. *Under review at Nature*

2.) Schutte-Engel, J., Marsh, D. J. E., Millar, A. J., Sekina, A., Chadha-day, F., Hoof, S., **Ali, M. N.,** Fong, K. C., Hardy, E., Smejkal, L. (2021): Axion Quasiparticles for Axion Dark Matter Detection. *Accepted at Journal of Cosmology and Astroparticle Physics.*

3.) Derunova, E., Gayles, J., Gaultois, M. W., **Ali, M. N.** (2021): Fermi Surface Geometry. *Submitted to Nature Physics*.

4.) Wang, Y., Yang, S. Y., Ortiz, B., Garg., C., Wu, H., **Ali, M. N.** (2021): Proximity-induced spin-triplet superconductivity and edge supercurrent in the topological Kagome metal, KV_3Sb_5. *Under review at Nature Physics*.

Personal Information

Family name, First name:	Steele, Gary
Nationality:	Canada
Website:	http://steelelab.tudelft.nl

Education

2006	PhD Physics, Massachusetts Institute of Technology, Cambridge, USA *Supervisor: Prof. Raymond Ashoori*
1999	BSc Honours Physics, McGill University, Canada

Employment

2018 – present	Full Professor Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands
2015 – 2018	Associate Professor Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands
2010 – 2015	Assistant Professor (tenured June 2015) Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands
2006 – 2010	Postdoctoral Researcher Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands *Supervisor: Prof. Leo Kouwenhoven*
1999 – 2006	Research Assistant Massachusetts Institute of Technology, Cambridge, USA *Supervisor: Prof. Raymond Ashoori*

Scientific output

2010-present	Publications:	>78
	Total citations (Google):	10531
	h-index (Google):	39
2010-present	Invited Talks:	>60

Teaching

2019 – present	Quantum Sensing and Measuremetn (TN3155) 3 ECTS Core course of the Quantum Minor ~30 students / year
2018 – present	Computational Science (TN2513) 3 ECTS Core course of 2nd year BSc Applied Physics program ~150 students / year
2017 – present	First year lab course (TN1405) 1 ECTS contribution Introduction to programming with python ~300 students / year
2010 – present	Honours Track (TN2110) Quantum Nanoscience Journal Club component (3x 2 hour lectures) 2nd year BSc Applied Physics program ~ 15 students / year
2012 – 2017	Kwantummechanica I (TN2302), 3 ECTS Core course of 2nd year BSc Applied Physics program ~150 students / year
2013 – 2018	Nanotechnology (AP3221D), 6 ECTS 1st year MSc Applied Physics program, ~30 students / year

2010 – 2015	Propedeutisch eindproject TN (TN1603) (Experimental end-project) 1st year BSc Applied Physics program ~ 10 - 15 students / year
2011 – 2014	Basis Kwalificatie Onderwijs (BKO) Traject, completed 2014

Supervision

2010 – present	Scientific Supervisor of >8 Postdocs, >14 PhD students, >10 MSc students, >15 BSc students *Current group:* 5 Postdocs, 7 PhD students, 6 MSc students
2006 – 2010	Daily supervisor of 4 MSc students, 1 BSc student during postdoc
1999 – 2010	Massachusetts Institute of Technology: Supervisor of 1 BSc student

Valorization

2017	Patent Granted for Vacuum Gap Qubit
2017 – present	Scientific advisor for Delft Circuits startup company
2016 – present	Partner with IBM, ST Microelectronics, Bosch, and Thales in OMT and HOT projects
2013 – present	Collaboration with Peter Steeneken from NXP on NEMS sensors
2014	Academic Advisor at FOM Physics with Industry program

Outreach and Science Communication

2016	Contribution of a physics question to the PION 2016 competition
2016	Organiser of the "Quantum Levitation Lab" Kidslab at TNW Family Day
2015 – present	Quantum Nanoscience meeloopdagen representative (presentation, lab tour, and "proefjes")
2015	Interview (in Dutch) on national television about applications of graphene mechanical resonators (*NOS Journaal, NOS op 3 edition*)
2014	Popular science article contribution to website *2physics.org* about graphene optomechanics with superconducting cavities
2014	Interview for website *nu.nl* on the applications of graphene
2014	Interview for short articles in national newspapers (*NRC* and *Volkskrant*) on quantum applications of graphene drums
2009	Interview (in Dutch) on national radio (*BNN*) about carbon nanotube nanomechanical resonators
2009	Interview for article about Klein tunneling in carbon nanotubes in weekend science pages of national newspaper (*NRC*)

List of Publications

See list at https://steelelab.tudelft.nl/publications/

Heng Wu

Curriculum Vitae and list of publications

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Professional experience

Aug. 2021 – present: **postdoctoral researcher** at Delft University of Technology (The Netherlands).

Advisor: Prof. Mazhar Ali

Research focus:

- Study on the fundamental mechanism of field-induced and field-free Josephson diode effects in Josephson junctions based van der Waals heterostructures
- Exploration on the emergent phenomenon between superconducting and novel quantum materials

Jul. 2020 – Jul. 2021: **visiting scholar** at Max Planck Institute of Microstructure Physics (Germany).

Advisor: Dr. Mazhar Ali

Sep. 2019 – Jul. 2021: **postdoctoral researcher** at Shenzhen University (China).

Advisor: Prof. Yu-Jia Zeng

Research focus:

- Growth of van der Waals material $TaCoTe_2$ single crystals and related transport properties investigation on its flake
- Exploration of Josephson effect based on 2D Kagome materials
- Study of the superconducting diode effect in vertical Josephson junctions based on 2D heterostructures

Sep. 2013 – Jul. 2019: **Ph.D** in Physics at Nanjing University (China).

Supervisor: Prof. Xinhua Zhu

Thesis: "Property modulation and microstructures of multiferroic (double-) perovskite oxides"

Research focus:

- Fabrication of $BiFeO_3$ nanoparticles and ceramics with various elements substitutions via different methods
- Investigation on the structural, magnetic, dielectric and electrical properties evolution of $BiFeO_3$ with various elemental substitutions and morphologies
- Researches on fabrications and physical properties studies of double perovskite ceramics

Education

Jul. 2019	**Ph.D.** in **Physics**	Nanjing University
Jun. 2013	**Bachelor (B.Sc.)** in **Physics**	Zhengzhou University

Scientific research skills

- **Materials fabrication**
  - nanoparticles fabrication via sol-gel method, (microwave-)hydrothermal method, molten salt process method
  - ceramic fabrication via solid state reaction (under high pressure)
  - Single crystal growth via chemical vapor transmission
- **Structural characterization**
  - XRD (including Rietveld refinement)
  - SEM for morphology characterization including EDS for element analysis
  - Raman spectra, FTIR
  - TEM (JOEL 4000, FEI Tecnai F20) for microstructure characterization
  - AFM (Bruker) for surface characterization
- **Device fabrication**
  - Mechanical exfoliation of 2D materials in glovebox with inert atmosphere
  - Transfer technique for 2D materials heterostructure fabrication
  - Electron beam lithography (Raith Pioneer Two)
  - Ion beam etching
  - Electrodes deposition via sputtering
- **Physical properties characterization**
  - Operation of dry-He 9T and 14T PPMS/Dynacool (base temperature of 1.7 K) of Quantum Design
  - Operation of He_3/He_4 mixture dilution refrigerator Bluefors (9T by 3T magnets, base temperature: 10 mK)
  - Operation of VSM of Quantum Design
- **Programming**
  - Python for data collection, visualization, analysis and communication with various instruments
  - LabView for communication with various instruments and data collection
  - experienced with C programming language, familiar with C++ and Java.

Peer-reviewed publication:

1. **Heng Wu**, Z. Pei, W. Xia, Y. Lu, K. Leng, X. Zhu. "Structural, magnetic, dielectric and optical properties of double-perovskite Bi_2FeCrO_6 ceramics synthesized under high pressure." *Journal of Alloys and Compounds*, **819** 153007 (2020).

2. Z. Pei, K. Leng, W. Xia, Y. Lu, **Heng Wu**, X. Zhu. "Structural characterization, dielectric, magnetic and optical properties of double perovskite Bi_2FeMnO_6 ceramics." *Journal of Magnetism and Magnetic Materials*, **508** 166891 (2020).

3. Y. Lu, Z. Pei, **Heng Wu**, K. Leng, W. Xia, X. Zhu. "Preparation of Ba_2FeNbO_6 double perovskite ceramics from molten-salt synthesized powders and their dielectric and magnetic properties." *Journal of Materials Science*, **55** [10] 4179-4192 (2020).

4. P. Xue, **Heng Wu**, W. Xia, Z. Pei, Y. Lu, X. Zhu. "Molten salt synthesis of $BaTiO_3$ nanorods: Dielectric, optical properties, and structural characterizations." *Journal of the American Ceramic Society*, **102** [5] 2325-2336 (2019).

5. **Heng Wu**, X. Zhu. "Microstructures, magnetic, and dielectric properties of Ba-doped $BiFeO_3$ nanoparticles synthesized via molten salt route." *Journal of the American Ceramic Society*, **102** [8] 4698-4709 (2019).

6. Y. Wang*, L. Wang*, X. Liu, **Heng Wu**, P. Wang, D. Yan, B. Cheng, Y. Shi, K. Watanabe, T. Taniguchi, F. Miao. "Direct Evidence for Charge Compensation-Induced Large Magnetoresistance in Thin WTe_2." *Nano letters*, **19** [6] 3969-3975 (2019).

7. X. Wang, K. Leng, Z. Pei, W. Xia, **Heng Wu**, Y. Lu, X. Zhu. "Microstructural characterization and dielectric properties of single crystalline $BaTi_2O_5$ nanowires prepared by molten-salt method." *SN Applied Sciences*, **1** [6] 528 (2019).

8. Q. Ji, P. Xue, **Heng Wu**, Z. Pei, X. Zhu. "Structural characterizations and dielectric properties of sphere-and rod-like $PbTiO_3$ powders synthesized via molten salt synthesis." *Nanoscale research letters*, **14** [1] 62 (2019).

9. P. Xue, **Heng Wu**, Y. Lu, X. Zhu. "Recent progress in molten salt synthesis of low-dimensional perovskite oxide nanostructures, structural characterization, properties, and functional applications: a review." *Journal of materials science & technology*, **34** [6] 914-930 (2018).

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1. **Heng Wu**, Yaojia Wang, Yuanfeng Xu, Pranava K. Sivakumar, Chris Pasco, Stuart SP Parkin, Yu-Jia Zeng, Tyrel McQueen, and Mazhar N. Ali. "Realization of the field-free Josephson diode." arXiv:2103.15809 (2021). (under review in *Nature*)

2. Heng Wu, Yaojia Wang, Noah Fan Qi Yuan, Liang Fu, Mazhar Ali. "Field-induced superconducting diode effect in twisted $NbSe_2/NbSe_2$ junctions." (in preparation)

Conference talks

1. **Heng Wu**, Xinhua Zhu. "Fabrication and Structural Characterization of $BiFeO_3$ Low-Dimensional Nanostructures", The 9th Asian Meeting on Ferroelectrics joint with The 9th Asian Meeting on Electroceramics (AMF-AMEC-2014), Shanghai, China.

2. **Heng Wu**, Xinhua Zhu. "Synthesis of Single-crystalline $BiFeO_3$ Nanoparticles and Their Magnetic Properties", International Conference on Technologically Advanced Materials & Asian Meeting on Ferroelectrics (ICTAM-AFM10), Delhi, India.

3. **Heng Wu**, Xinhua Zhu. “Synthesis, microstructural characterization and magnetic properties of Ba-doped bismuth ferrite nanoparticles”, joint conference between IEEE-International Symposium on Applications of Ferroelectrics (ISAF), Meeting on Ferroelectric Materials and Their Applications (FMA), Asian Meetings on Ferroelectrics (AMF), Asian Meetings on Electroceramics (AMEC) and Piezoresponse Force Microscopy Workshop (PFM) (IFAAP 2018), Hiroshima, Japan.