Peir-Ru, Wang (Louis)

Materials Science | Mechanical Engineering | Superconductivity | Quantum Physics

EXPERIENCE

National Tsing Hua University (NTHU) 2024.03–2024.09

Postdoc in Materials Science and Engineering

Investigate quantum properties of spiral TaS_2 using Scanning Tunneling Microscopy.

INVENTION PATENTS

United States Invention Patent

Continuously Variable Transmission

US 10030745 B2

- This self-adaptable, positive motion CVT is able to transmit power by way of engagement.
- Able to transmit a torque density **8 times** larger than the traditional design.

Taiwan Invention Patent

Continuously Variable Transmission

I580876

PUBLICATIONS

The Effect of Critical Coupling Constants on Superconductivity Enhancement

Nature Scientific Report 13, 6475 (2023) (Impact Factor: 4.997)

- The theory of critical coupling constants **unifies** the effects of the phonon frequency Ω, the carrier number Z, and the pressure P on superconductivity.
- Demonstrate **general zigzag methods** for T_c enhancement.

Low Speed Wind Tunnel Study of Variable Tandem Wing Aircraft Design

A.A.S.R.C Conference (2014)

- The variable tandem wing design can **increase 33%** lifting force.

LABORATORY AUTOMATION

Resistivity-Temperature ρ-T Measurement Automation

- Temperature 70K~400K, resistivity $1\mu\Omega \cdot \mathrm{cm} \sim 1\mathrm{G}\Omega \cdot \mathrm{cm}$
- Program LabVIEW codes to control and collect information from the instruments, including Keithley, HP, Stanford Research Systems, and Cryo-Con.

Chemical Powder Mixture Preparation Automation

- Prepare 96 different mixtures within 14 hours and 40 types of powder for selections.

EDUCATION

National Tsing Hua University (NTHU) 2016.09–2024.01

Ph.D. in Materials Science and Engineering

National Tsing Hua University (NTHU) 2012.09–2016.06

B.S. in Power Mechanical Engineering

Minor in Physics

TEACHING ASSISTANT

NTHU Outstanding Teaching Assistant Award (2019)

TA Courses:

- General Relativity I & II
- Classical Mechanics
- Theoretical Mechanics II
- Statistical and Thermal Physics I & II
- Fluid Dynamics
- General Physics I & II

COURSES WITH GOOD PERFORMANCE

Studied across various subjects, including **materials science, mechanical engineering**, **physics**, and **mathematics**. Capable of **integrating and applying knowledge from multiple fields.**

Materials Science:

- Phase Equilibria of Materials (A+)
- Thermodynamics of Solid State (A)
- Ceramic Materials (A)
- Transmission Electron Microscopy (A)

Power Mechanical Engineering

- Thermal and Fluid Science I (A+)
- Introduction to Nuclear Engineering (A+)
- Electric Circuits (A+)
- Kinematics of Machinery (A)
- Vehicle Power System (A)
- Programming Language (A+)
- Engineering Mathematics II (A+)
- Heat and Mass Transfer (A)
- Manufacturing Processes (A)
- Energy Engineering (A)

Physics:

- String Theory (A+)
- Elementary Particle Physics I (A+)
- Theoretical Mechanics Il (A+)
- Statistical Mechanics II (A)
- Fluid Dynamics (A+)
- Nonlinear Dynamics and Chaos (A+)
- Quantum Field Theory (A)

Mathematics:

- Advanced Calculus I (A+)

SKILLS

- LabVIEW
- AutoCAD
- 3D Printing
- Arduino
- MATLAB
- Python
- VBA
- C

CERTIFICATE

- TOEIC 880 (Gold)

LINKEDIN

- https://www.linkedin.com/in/peir-ru-wang

WEBSITE

- https://pure-perspective.github.io/career/CV.html

▶ *The Self-Adaptable Positive Motion CVT Invention Patents*

US Invention Patent 10030745 B2: ppubs.uspto.gov/dirsearch-public/print/downloadPdf/10030745

Taiwan Invention Patent I580876: twpat1.tipo.gov.tw/twpatc/twpatkm?!!FRURLI580876@@gpss

I studied and invented ***the self-adaptable, positive motion continuously variable transmission (CVT).*** Traditional CVTs using friction transmission cannot achieve high torque output. This self-adaptable, positive motion CVT is able to transmit power by way of engagement, such that the coupling between the power transmission mechanism and the conical disk is more stable than the conventional friction CVT. Thus, this invention can transmit a torque density ***8 times*** larger than the traditional design, making it ***competitive in high-torque applications***.

US010030745B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 10,030,745 B2**
(45) **Date of Patent:** **Jul. 24, 2018**

(54) **CONTINUOUSLY VARIABLE TRANSMISSION**

(71) Applicant: **NATIONAL TSING HUA UNIVERSITY**, Hsinchu (TW)

(72) Inventors: **Pair-Ru Wang**, Hsinchu (TW); **Tzu-Yang Cheng**, Lukang Township, Changhua County (TW); **Hsiao-Wei Chiang**, Hsinchu (TW)

(73) Assignee: **NATIONAL TSING HUA UNIVERSITY**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 274 days.

(21) Appl. No.: **15/175,887**

(22) Filed: **Jun. 7, 2016**

(65) **Prior Publication Data**

US 2017/0248207 A1 Aug. 31, 2017

(30) **Foreign Application Priority Data**

Feb. 26, 2016 (TW) .... 105105774 A

(51) **Int. Cl.**
F16H 9/24 (2006.01)

(52) **U.S. Cl.**
CPC ***F16H 9/24*** (2013.01)

(58) **Field of Classification Search**
CPC F16H 9/24; F16H 9/10; F16H 9/18; F16H 55/56; F16H 55/38; F16H 37/0846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,049,113 A *	9/1991	Graham, Jr.	F16H 55/38 474/13
9,855,993 B2 *	1/2018	Rockwood	F16H 9/24
2011/0053717 A1 *	3/2011	Miura	F16H 9/18 474/46
2011/0059821 A1 *	3/2011	Lee	F16H 9/10 474/8

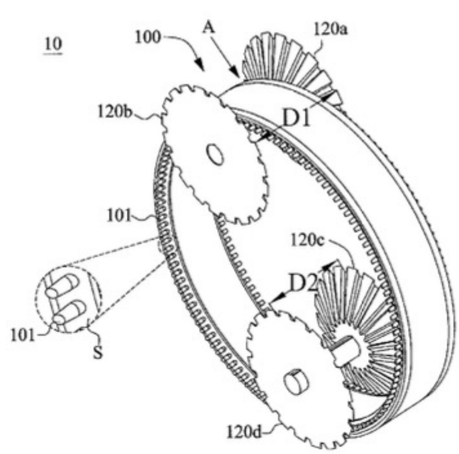
* cited by examiner

Primary Examiner — William E Dondero
Assistant Examiner — Robert T Reese
(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(57) **ABSTRACT**

A continuously variable transmission (CVT) includes a power transmission mechanism and at least one conical disk. The power transmission mechanism has a contact surface, and the power transmission mechanism includes a plurality of engaging elements. The plurality of engaging elements are retractably disposed on the contact surface. The disk surface of the conical disk has a plurality of engaging walls capable of engaging with the engaging elements. The continuously variable transmission is able to transmit power by way of engagement, such that the coupling between the power transmission mechanism and the conical disk is more stable. Thus, the continuously variable transmission is adaptable to high torsion application.

10 Claims, 15 Drawing Sheets

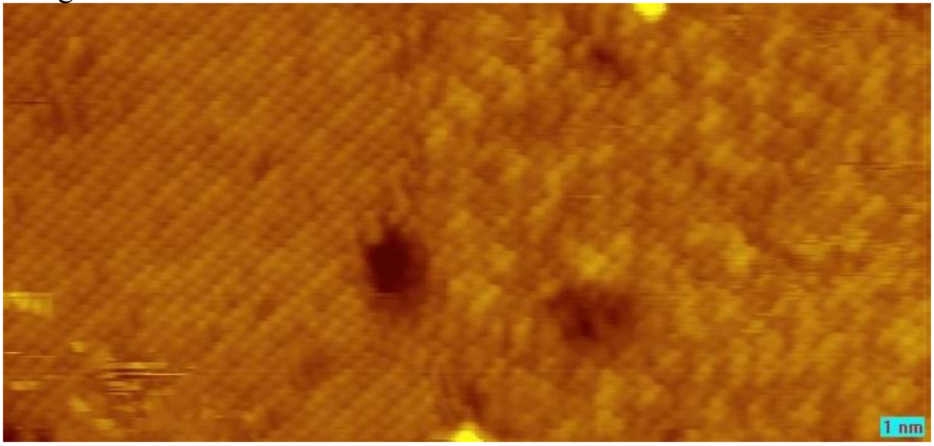


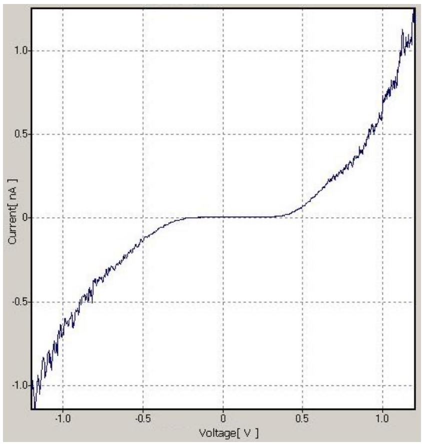
▲ United States patent certificate.

▶ STM Studies of TaS_2: Insights into Quantum Properties (Postdoc)

In my recent postdoctoral research, I have focused on 2D quantum materials, particularly Transition Metal Dichalcogenides (TMDs) such as TaS_2, NbS_2, and VS_2. These van der Waals layered materials exhibit remarkable properties, including superconductivity, charge density waves, and Moiré phenomena, making them a promising platform for advancing quantum materials research. Scanning Tunneling Microscopy (STM) plays a crucial role in quantum physics by enabling direct, atomic-scale probing of the local electronic density of states, allowing researchers to observe and understand quantum phenomena at the surface level. By using STM, I gain invaluable insights into the physical properties and electronic behaviors of these materials, facilitating a deeper understanding of their quantum nature.

I have hands-on experience with maintaining and operating UNISOKU's STM USM-1400 system. Recently, my work with CVD-grown spiral TaS_2 involved capturing high-resolution STM images at both room temperature and 77K. I observed stoichiometric and non-stoichiometric transitions in spiral TaS_2, demonstrating the capability of CVD growth methods for fine-tuning chemical composition and providing a versatile platform for exploring novel physical phenomena. Additionally, the I-V curve analysis reveals a gap feature in TaS_2, which may indicate the presence of a Mott gap, offering further insight into its electronic structure.





▲ (Left) This image demonstrates the transition from the stoichiometric phase to the non-stoichiometric phase of TaS_2, showcasing the power of the CVD growth method in precisely tuning chemical composition. (Right) The I-V curve reveals the gap nature of TaS_2, potentially indicating a Mott gap, providing valuable insight into its electronic structure and the underlying quantum behaviors.

▶ Research on Enhancing Superconductivity Through Materials Design

My doctoral research focused on ***how to enhance superconductivity at ambient pressure through materials design***. Observing the critical temperature of superconductors, one finds that it increases with the diversity of compound compositions. Extrapolating from this trend, it is anticipated that oxides containing 12 or more elements could achieve room-temperature superconductivity. If we select 12 elements from a commonly used set of 80 elements, there would be at least $\boldsymbol{C_{12}^{80} \cong 10^{14}}$ possible combinations! I increased research efficiency from 3 aspects:

1. ***Propose the theory of critical coupling constants***, using this theory to design chemical formulas.
2. ***Automate the preparation of oxide powder compositions*** to enhance efficiency.
3. ***Automate the resistivity temperature ρ-T measurements***, witch can simultaneously measure multiple samples.

▶ ***Theory of Critical Coupling Constants*** published in ***Nature Scientific Reports*** (***Impact Factor 4.997***)

DOI:10.1038/s41598-023-33809-5

My Ph.D. thesis is "*The effect of critical coupling constants on superconductivity enhancement*". In the thesis, it clearly elaborated that the ***superconducting dome appears when the coupling strength approached to the critical coupling constants***. Varying the phonon spectrum Ω, tuning the carrier number Z, and increasing the pressure P were three important approaches to enhance superconductivity T_c. I extended the ***BCS-McMillan theory:***

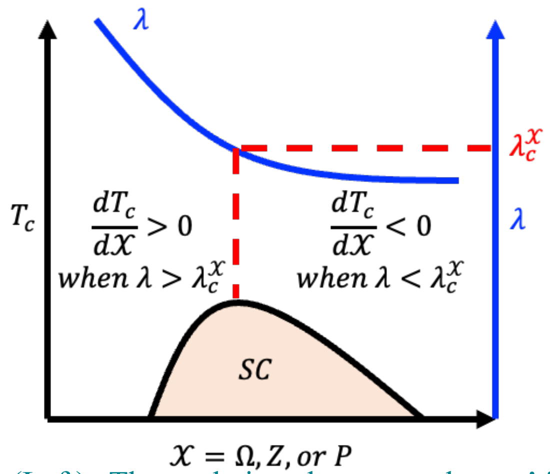
$$\hat{H}|\Psi\rangle = \left[\sum_{k\sigma} \xi_k c_{k\sigma}^{\dagger} c_{k\sigma} + \frac{1}{N}\sum_{kk'} \frac{g_{eff}}{M\Omega^2} c_{k\uparrow}^{\dagger} c_{-k\downarrow}^{\dagger} c_{-k'\downarrow} c_{k'\uparrow}\right]|\Psi\rangle$$

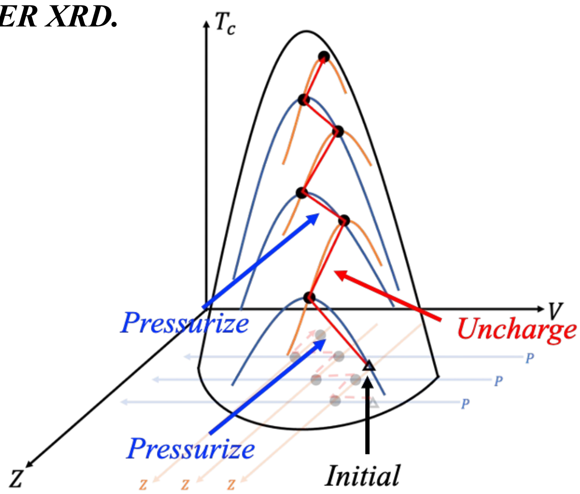
to unify effects of the phonon frequency Ω, the carrier number Z, and the pressure P on superconductivity. I derived the explicit form of coupling constant λ and T_c :

$$\lambda = \frac{C\sqrt[3]{Zn_{ion}}}{M\Omega^2} \quad and \quad T_c \sim \Omega \cdot exp\left[-\frac{M\Omega^2}{C\sqrt[3]{Zn_{ion}}}\right]$$

. These equations defined the ***three critical coupling constants*** $\boldsymbol{\lambda_c}$: $\boldsymbol{\lambda_c^{\Omega} = 2}$, $\boldsymbol{\lambda_c^{Z} = 5/3}$, and $\boldsymbol{\lambda_c^{P} = 4/3}$.

These critical coupling constants ***are consistent with experimental observations*** and ***quantitatively classify superconductivity into three categories: weak*** $(\boldsymbol{\lambda < \lambda_c^P})$ ***, intermediate*** $(\boldsymbol{\lambda_c^P < \lambda < \lambda_c^{\Omega}})$ ***, and strong coupling*** $(\boldsymbol{\lambda > \lambda_c^{\Omega}})$ **.** Each category corresponds to different enhancement strategies. More precisely, the enhancement strategies for ***weak and strong coupling regions are opposite***, but ***both inevitably bring superconductivity into the intermediate coupling region***. For superconductors in the intermediate coupling region, for example, the superconductivity can be enhanced by increasing P or decreasing Z simultaneously. This ***general zigzag strategies*** can further enhance the superconductivity. According to the theory, I focused on the chemical design including high phonon frequency, multiple carriers, and small lattice constants. I synthesized a series of high-entropy oxides based on $\boldsymbol{Bi_2Sr_2Ca_2Cu_3O_x}$ and $\boldsymbol{YBa_2Cu_3O_x}$ superconductors. The micro structure of the HE compounds was analyzed by ***ZEISS Gemini SEM*** and ***Bruker D2 PHASER XRD.***





▲ (Left) The relation between the ***critical coupling constant*** $\boldsymbol{\lambda_c}$ and the ***superconducting dome***.

▲ (Right) ***The general zigzag strategies*** further enhance superconductivity by pressurizing and decharging.

▶ *The Powder Mixing Robotic*, and *ρ-T Measurements Automation*

More details: pure-perspective.github.io/career/CV.html

The chemical powder mixture preparation automation can prepare ***96 different mixtures within 14 hours***, which is ***6 times faster*** than manual preparation. The machine offers ***40 types*** of powder for selections. I designed components using ***AutoCAD*** and printed them with ***Ender-3S 3D printer***. I also soldered electronic components onto circuit boards to control the step motors. 12 step motors controlled the XY motions of the powder boxes and the empty bottles. The weight of powder mixture is measured by ***Shimadzu ATY-124*** balance. The control program integrated ***LabVIEW, Arduino, and VBA.*** This machine can weigh the powder according to the user's experimental design and record any discrepancies.

The resistivity-temperature $\rho - T$ measurement automation can measure ***15 oxide or alloy pallets simultaneously*** with the temperature range from ***70K to 400K***. The range of resistivity covers $\boldsymbol{1\mu\Omega \cdot cm}$ ***to*** $\boldsymbol{1G\Omega \cdot cm}$. ***LabVIEW*** codes control and collect information from the instruments through ***GPIB***. Instruments include ***Keithley 237 and 617 meters***, ***HP34420A meter***, ***Stanford Research Systems SR830 Lock-in***, and ***Cryo-Con 32B temperature controller***. The modular design of the measurement circuit allows for easy expansion and routine maintenance.

▶ *Teaching Assistant in Physics* and *Recognized Outstanding TA Award*

TA Award: mse.site.nthu.edu.tw/p/405-1298-182360,c16769.php?Lang=en

I am the teaching assistant in ***statistical and thermal physics I & II***, ***general relativity I & II***, ***theoretical mechanics II***, ***fluid dynamics,*** classical mechanics, general physics I & II, etc. I was recognized with the ***NTHU Outstanding Teaching Assistant Award*** in *2019* due to dedicated teaching efforts.

▶ *Minor Degree in Physics(B.S.)* and *further studied physics during Ph.D.*

Beside the major subject in power mechanical engineering, I also have minor degree in physics. I have taken the courses including ***theoretical mechanics I & II, electromagnetism I & II, and quantum physics I.*** I am interesting in the variational principle of least action and the Noether's theorem, which imply the relation between the symmetry and the conservation law. These elegant results showed the beauty of physics, leading me to further study more physics courses and become TA in physics during my doctoral studies.

During my Ph.D. period, I further studied more advanced courses in physics. The superconductivity is a ***macroscopic quantum state***, typically explained through the concept of ***symmetry breaking***. I studied ***quantum field theory, statistical mechanics, and condensed matter physics*** to further investigate superconductivity. Additionally, to understand symmetry breaking, I studied ***elementary particle physics, gauge theory***, and even ***principal bundle theory*** from the Mathematics Department. The ***Ginzburg-Landau (GL) theory*** is one of the theories that explain superconductivity. I learned to use ***MATLAB*** to simulate the phase separation in GL theory during the course on ***nonlinear dynamics and chaos***.

國立清華大學學士學位證書

清（一〇五）大字第一三二三 號
學號 一〇一〇一一一二四

王 培 儒 生於中華民國
在本校 工 學 院 動 力 機 械 工 程 學 系 學士班
修 業 期 滿 成 績 及 格 依 學 位 授 予 法 之 規 定 授 予
工學學士學位
此證

校長 賀陳弘

持證人選修 物理學系 學士班為輔系

中 華 民 國 一 〇 五 年 六 月

▲B.S. in ***Department of Power Mechanical Engineering*** at NTHU. Minor degree in ***Department of Physics***.

▶ *Wind Tunnel Study of Variable Tandem Wing Aircraft*

Article: pure-perspective.github.io/career/images/tandem/Tandem-Wing-article.pdf

During my bachelor's studies, I studied on the ***aerodynamics of variable tandem wing aircraft.*** The variable tandem wing design can change the center of lift to match the center of gravity. This design can ***increase 33% lift and optimize the aerodynamic efficiency.*** The model aircraft was set up in the wind tunnel, and measure the lift force and the drag force to investigate the aerodynamic performance. We summarized these result and published in ***Aeronautical and Astronautical Society of the Republic of China (A.A.S.R.C) 2014 conference***.

▶ *Cross-disciplinary Learning, Integrating and Applying Knowledge*

During my bachelor's and Ph.D. degrees, I studied across various disciplines, including ***mechanical engineering***, ***physics***, ***materials science***, and ***mathematics***. I ***maintained curiosity*** and ***strong learning capabilities***, ***integrating knowledge from multiple fields*** to advance the formulation of superconducting theories, the automation of measurement, and the powder mixing robotic. I have shown ***curiosity*** and ***gained expertise in various fields***, and I'm able to ***provide solutions to complex problems***!