Results from Survey at the 8th US-Japan Joint Seminar on Nanoscale Transport Phenomena

This document presents the results of a survey administered at the 8th US-Japan Joint Seminar on Nanoscale Transport Phenomena, held in Santa Cruz, CA, on July 24-26, 2014.

The following pages contain the original survey questions in plain black font, *and the* ***results and discussion in blue italic font****.* *In a few cases responses have been lightly edited for grammar.*

The survey was handed out in hard-copy form on the second day of the conference, and collected later that afternoon. In addition, one survey and another set of comments were received by email after the conference, and are also reflected in the results below. The total number of surveys returned represents a yield of approximately 50% of conference attendees.

The survey was prepared by the four conference organizers: C. Dames, P. Reddy, Y. Nagasaka, and H. Daiguji. The results were analyzed by C. Dames and F. Yang.

It is planned that the highlights of this survey will also be presented in an upcoming article in Nanoscale and Microscale Thermophysical Engineering *(*NMTE*).*

-C. Dames & F. Yang
September 2014.

SURVEY

The 8th US-Japan Joint Seminar on Nanoscale Transport Phenomena

Anonymous.

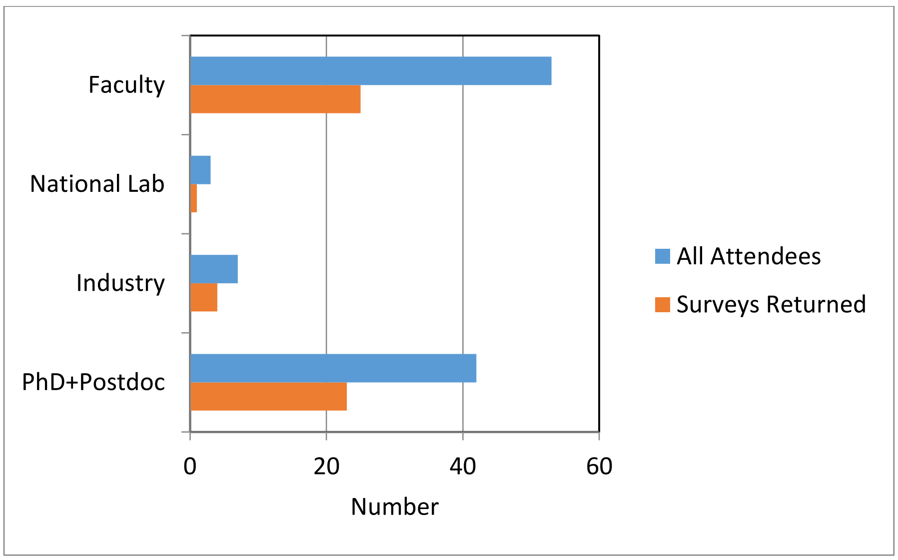
All questions are optional.

The results, in aggregate form, will be analyzed and shared with the community at the end of the conference on Wednesday, as well as a planned short article in Nanoscale and Microscale Thermophysical Engineering (NMTE).

Part I: Background

1) Your Position (circle one).

Grad. Student Postdoc Faculty National Lab Industry

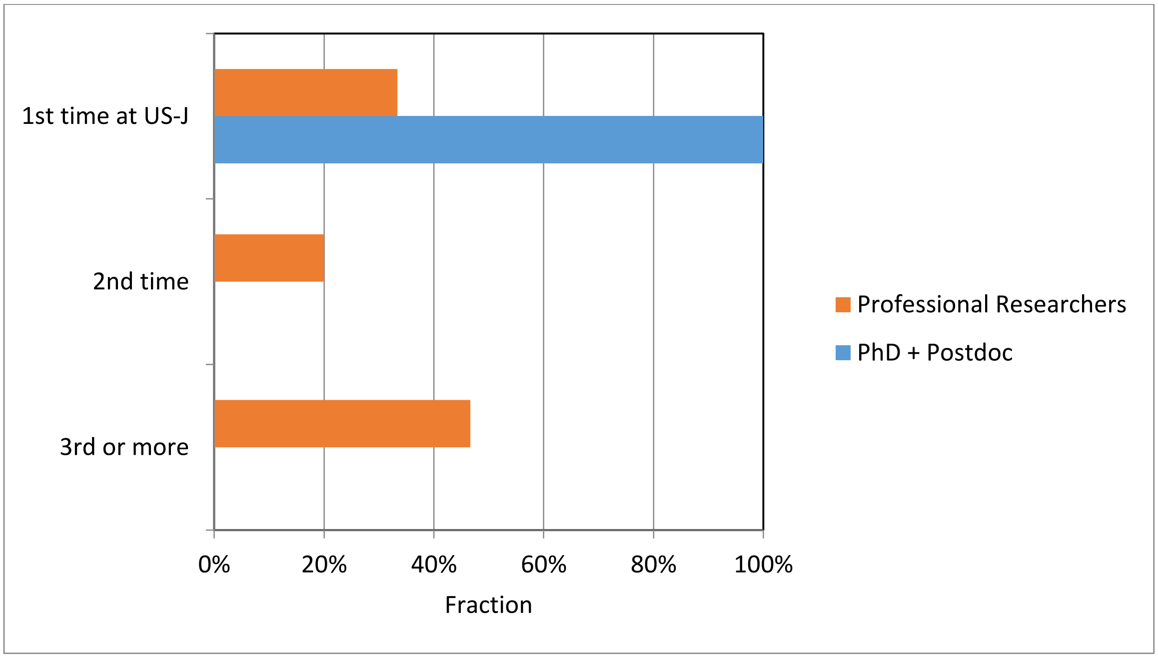


53 surveys received back. Yields were around 50% overall.

The survey results below are generally broken into two categories: "Professional Researchers" (Faculty + National Labs + Industry), N=30; and "PhD + Postdocs", N=23.

2) Your Prior Attendance at the US-Japan Series.

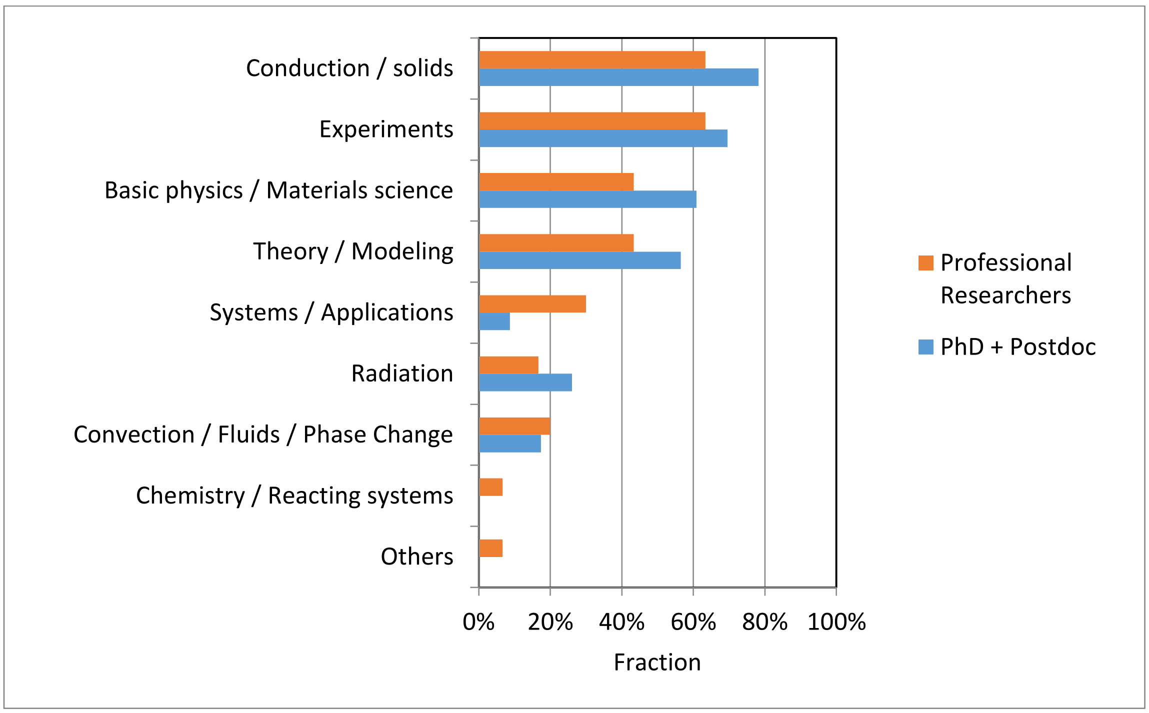
1st Time at US-Japan | 2nd Time | 3rd Time Or More



3) Primary Research Interest(s). Indicate one or more.

Conduction / Solids	Convection / Fluids / Phase Change	Radiation
Chemistry / Reacting Systems	Basic Physics / Materials Science	Systems / Applications
Theory / Modeling	Experiments	Other . . . .

Plot of Keyword Analysis: the percentage of survey respondents indicating this interest. Note there was no upper limit on the number of keywords that could be indicated.



Part II: Research

4) Major Accomplishments in Your Field. Thinking back 12 years (i.e., the time of the 2002 US-Japan meeting), list 1 to 3 of the most important advances in your field. This could be in theory, experiment, and/or application. (Order does not matter.)

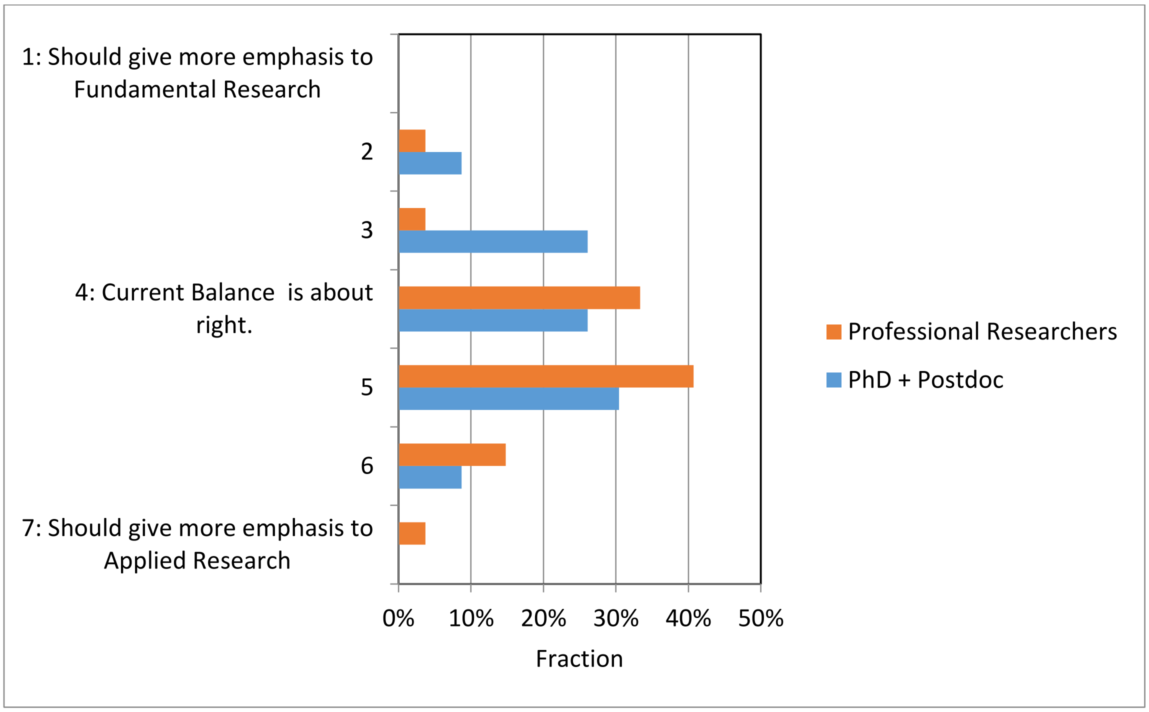
5) Grand Challenges in Your Field. Thinking ahead 12 years (i.e. the time of the 2026 US-Japan meeting), list 1 to 3 grand challenges on the horizon which you think your field might be able to address. (Order does not matter.)

Responses to Questions 4 & 5 given at end of this document.

6) Fundamentals, Applications, and Industry: In your field, how do you feel about the overall balance between fundamental versus applied research?

Should place more emphasis on *Fundamental Research* (and less on applications). ←			Current balance is about right. ↓			Should place more emphasis on *Applied Research* (and less on fundamentals) →
1	2	3	4	5	6	7

Comments?



Professional Researchers tended to believe their fields should place slightly more emphasis on Applied Research than they currently do (Mean = 4.7).

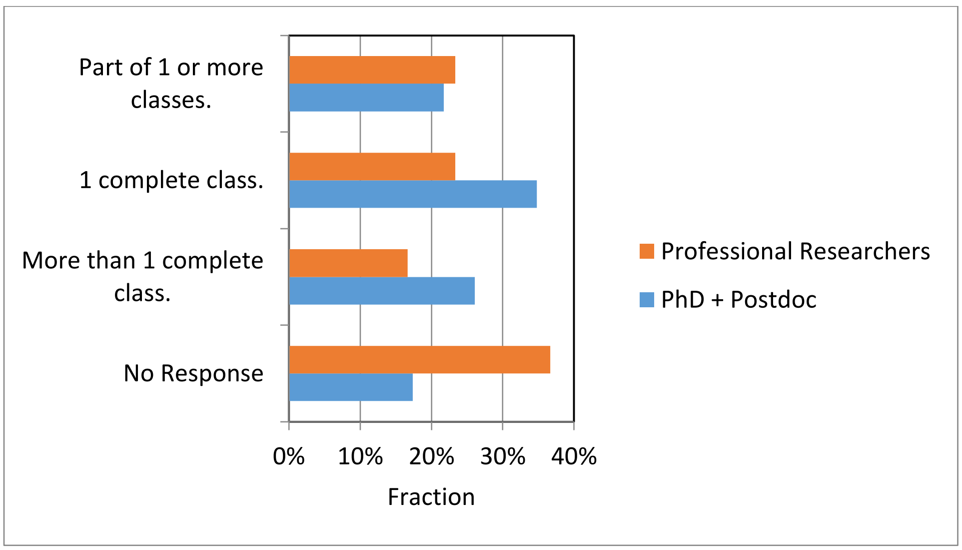
Students & Postdocs were evenly balanced (Mean = 4.0).

Part III: Teaching (for those affiliated with universities)

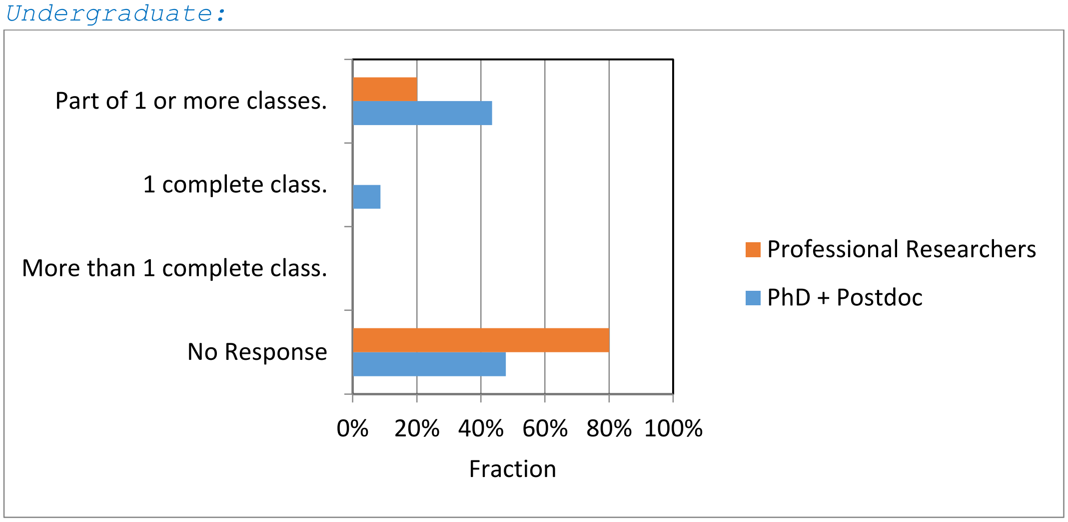
How is nanoscale transport phenomena included in the curriculum at your institution?

	Included as *part* of 1 or more class(es).	1 *complete* class.	More than 1 complete class.
7) Graduate Level:			
8) Undergraduate Level:			

Graduate:



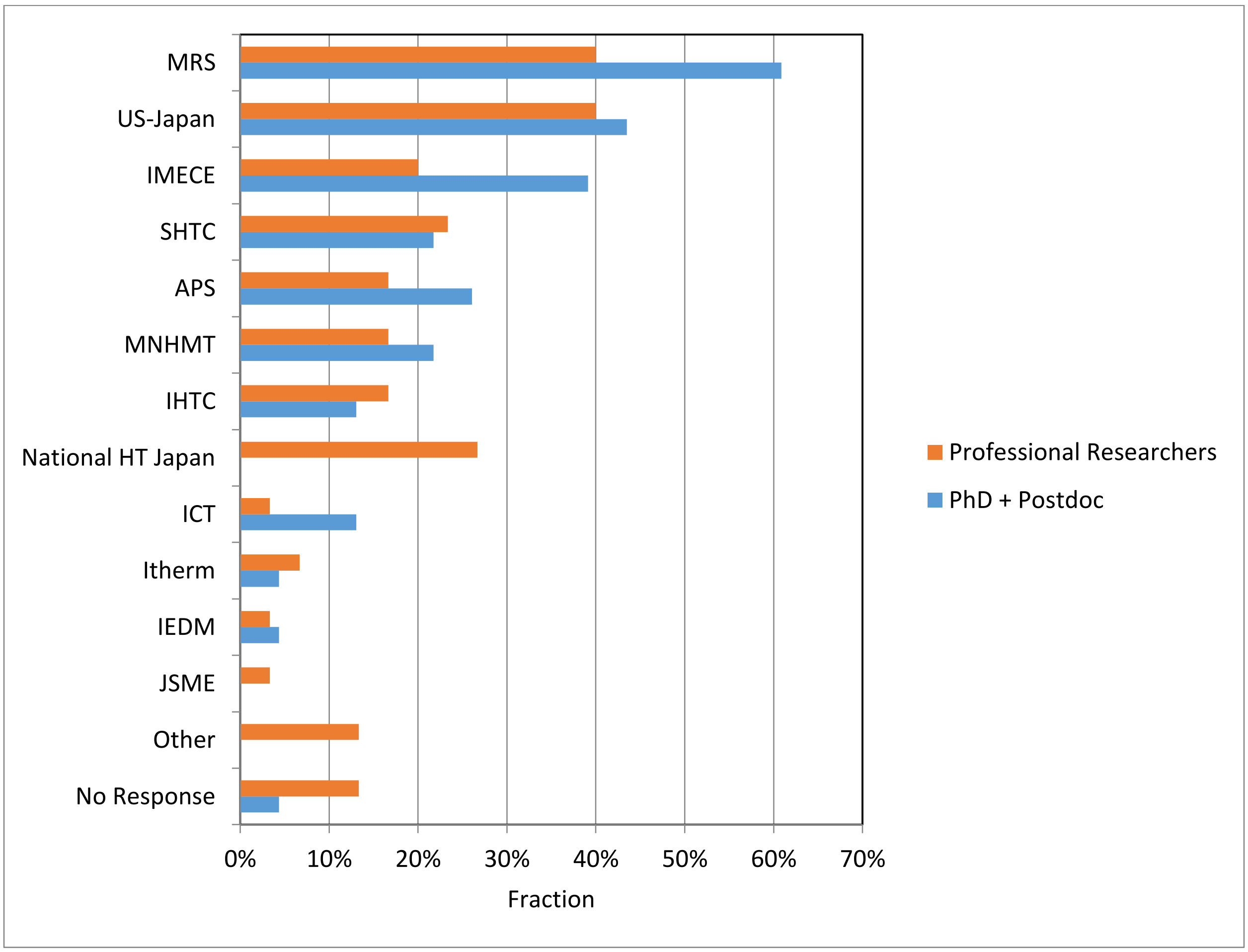
Undergraduate:



Part IV: The US-Japan Joint Seminar

9. Conference Context: Indicate up to 3 most important conferences in your field.

- ☐ APS March Meeting (American Physical Society)
- ☐ ICT (International Conference on Thermoelectrics)
- ☐ IEDM (IEEE International Electron Devices Meeting)
- ☐ IHTC (International Heat Transfer Conference)
- ☐ IMECE (ASME International Mechanical Engineering Congress & Exposition)
- ☐ InterPACK (International Electronic Packaging Technical Conference and Exhibition)
- ☐ ITherm (IEEE Intersoc. Conf. on Thermal & Thermomechanical Phenomena in Electronic Systems)
- ☐ JSME Thermal Engineering Conference
- ☐ MNHMT (ASME Micro/Nanoscale Heat & Mass Transfer International Conference)
- ☐ MRS (Materials Research Society)
- ☐ National Heat Transfer Symposium of Japan (The Heat Transfer Society of Japan)
- ☐ NEMB (ASME NanoEngineering for Medicine and Biology)
- ☐ SHTC (ASME Summer Heat Transfer Conference)
- ☐ US-Japan Joint Seminar on Nanoscale Transport Phenomena (this meeting)
- ☐ Other . . . .

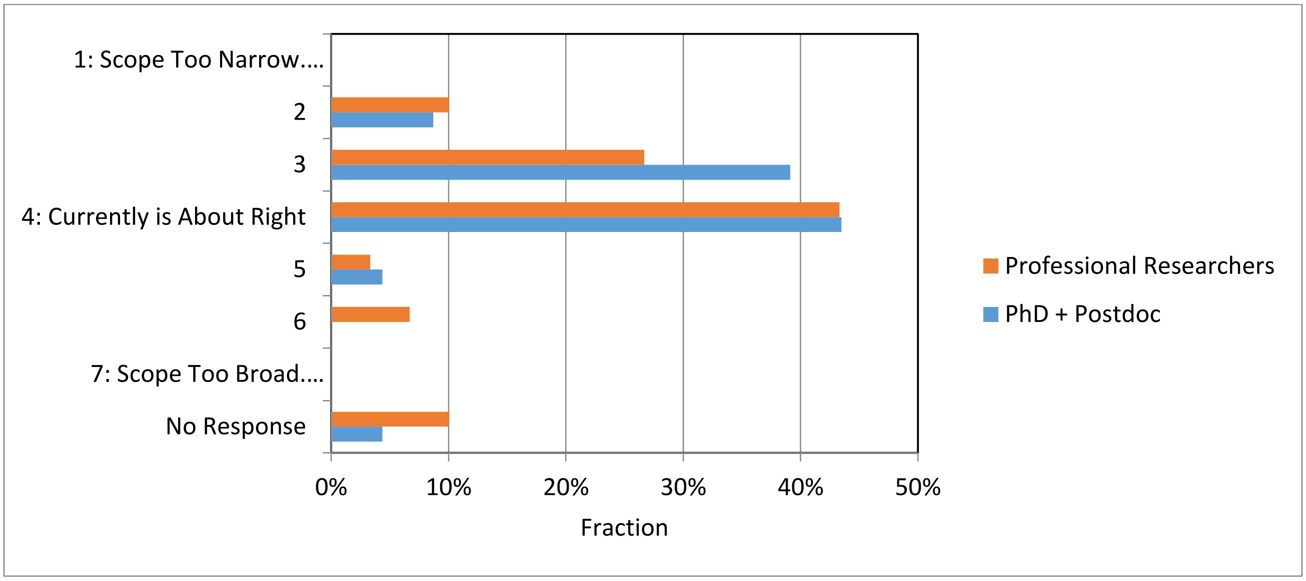


Note that respondents were limited to 3 selections.

10. Scope of the US-Japan Seminar: What do you think about the balance between "traditional" nanoscale transport researchers & topics, versus adjacent or non-traditional perspectives?

Current scope is too narrow: Should add additional topics ←			Current balance is about right ↓			Current scope is too broad: Should omit some topics →
1	2	3	4	5	6	7

Comments? (e.g., how to narrow or broaden scope?)



Means are 3.7 (Professional Researchers) and 3.5 (Students & Postdocs).

Comments:

"Invite leading experts in other field, especially the fields that are the motivation for nanoscale transport to give keynotes at this conference, or special folks."

"Organizers could look for and ask researchers doing interesting work that could be of interest to the community to come to the seminar to talk. Otherwise researchers attending who are already outside the field could be asked to identify other possible researchers to invite."

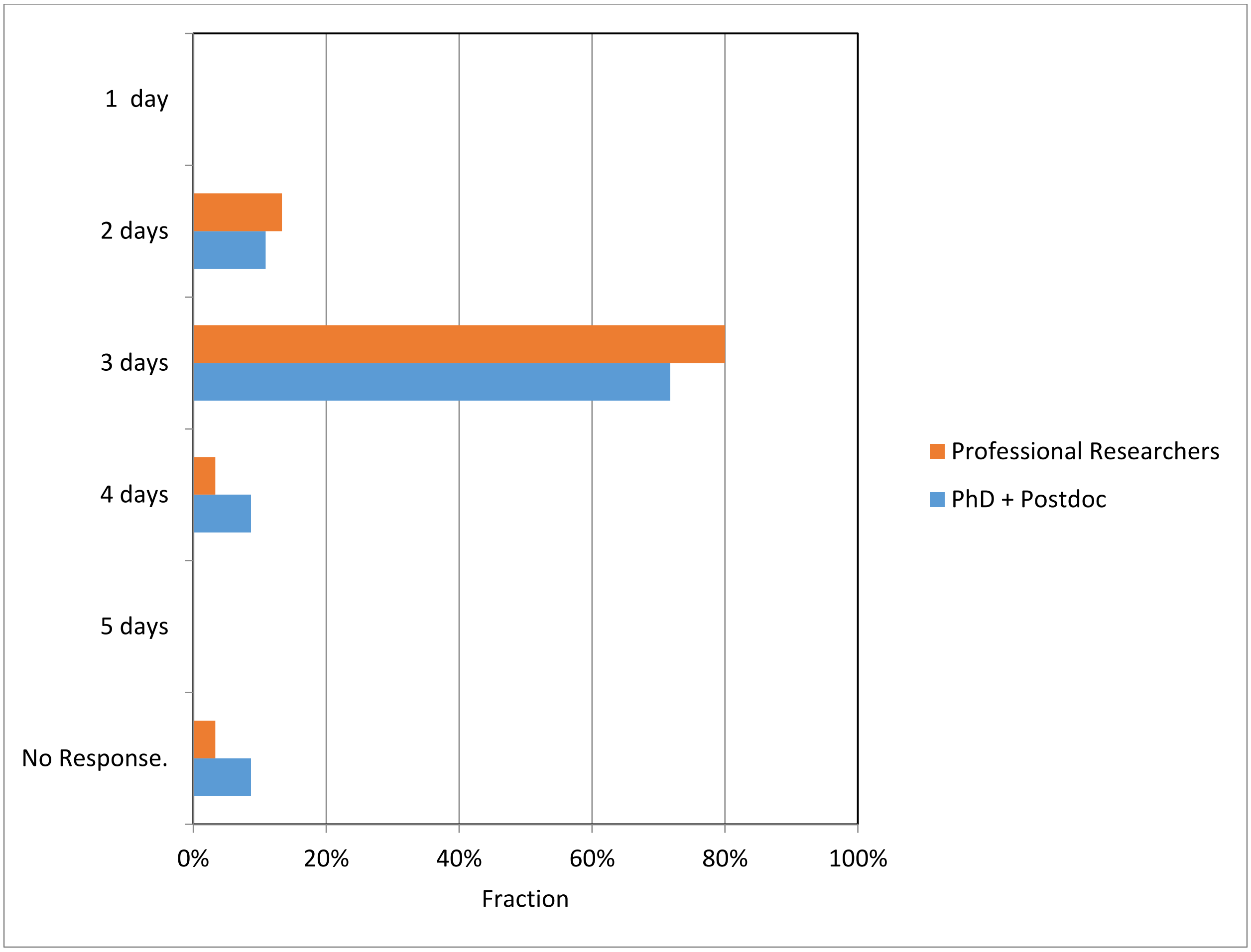
"Invite speakers with background in current challenging in existing industries. E.g. thermal issues in thermal power plants. Need more emphasis on energy/CO2 challenges."

"We should have certain core fields for continuing."

"This time, US researchers & topics seemed to be mostly regarding "phonons (heat conductions) in solids" which I felt a bit narrow. In the last seminar (7th) held in Shima-city of Japan, I saw several US researchers who were studying non-solid or molecule-based energy conversions such as [..], or optics topics such as [...]. In this time those people did not attend, which perhaps gave me an impression of a bit narrowed topic range. Although I do not have a specific idea to effectively broaden the scope, I just would like to explain this my impression."

11. *Length: Optimal length of a US-Japan Meeting (in days)?*

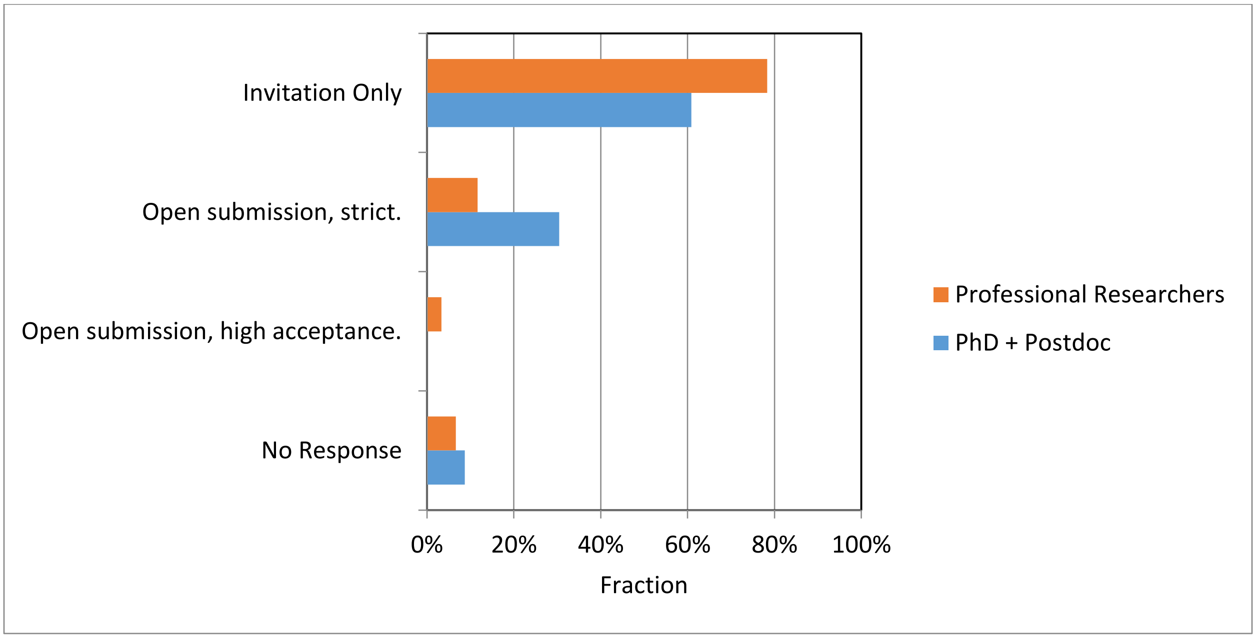
1 . 2 . 3 . 4 . 5



12. *Abstract Solicitation for US-Japan: Which do you prefer?*

By Invitation (current method).	Open Abstract Submission, then strict downselection by an organizing committee.	Open Abstract Submission, with very high acceptance rate.

Comments?



Comments:

"Invitation maintains the extremely high quality of talks and state of art."

"[Invitation only] to maintain certain number (not too many / too few) of a combination of participants with various interests."

"Prestige to be invited. But it would be nice to have open invitation to attend for all interested researchers (even w/o talks) Right now, it seems like you have to be in the right circle to get invited or even know about the conference."

"[Invitation only is] not great, but roughly easiest."

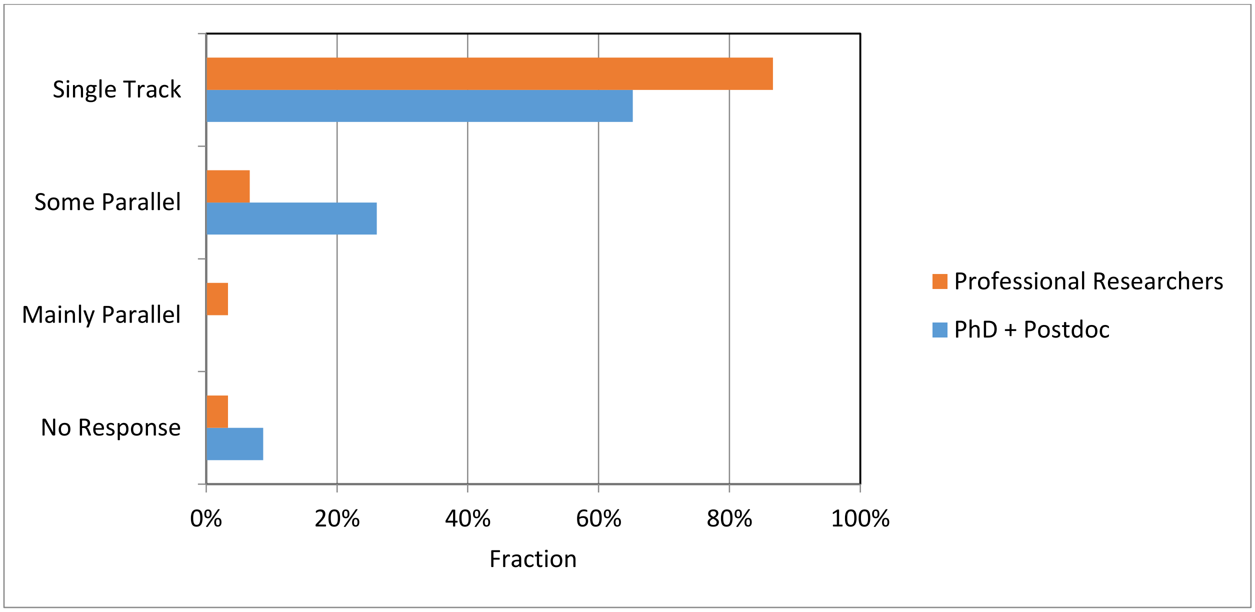
"Combination of by invitation (1) and open submission(2), although current method is also OK and a more intimate feeling."

"Invitation is good, but open submission could help broaden."

"Invitation-only may overlook important people and promotes a narrow focus."

13. *Parallel Sessions?*

Keep single track only.	Some parallel sessions are good.	Primarily parallel sessions (except for a few plenary talks).



Comments:

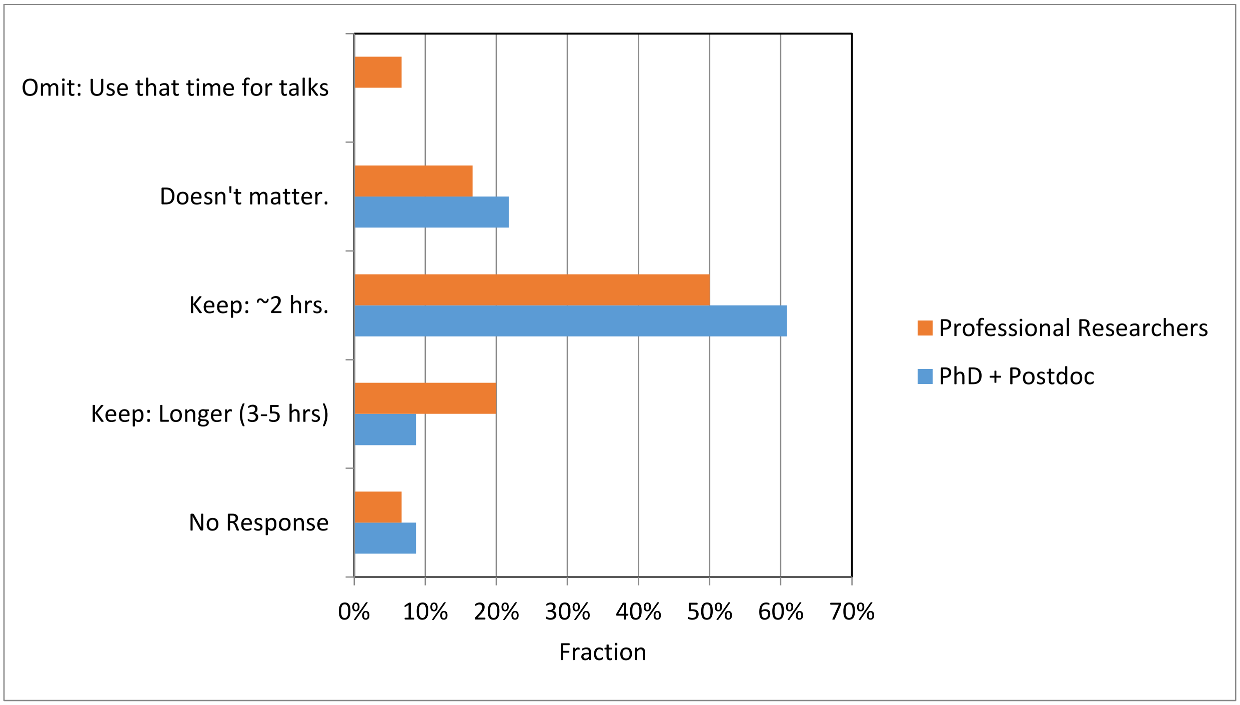
"Keeping single track is important to produce the cohesion of the community during this meetings."

"It seems like we run behind on all sessions and may need to lengthen the event."

""Nanoscale transport" is too narrow to split in [parallel?] sessions. This is a seminar, also, we may appreciate some lecture at some other later moment."

14. *Excursion: What do you think about having an excursion as an integral part of the US-Japan Meeting?*

Omit: Use that time for talks instead	Doesn't matter	Keep: ~2 hours is good	Keep: And make longer (3-5 hours)



The excursion was viewed positively by 70% of respondents, and neutrally by another 19%.

Comments:

"Informal interaction and forging contacts is critical."

"Making longer is important to promote friendship, discussion, see the place we are visiting."

"Keeping excursion should be a big burden for the chairs/cochairs, but it is really worth it."

15. *Improvements: Any other suggestions for the future of the US-Japan Seminar Series?*

Comments, grouped roughly into themes:

<u>Program and Speaker Selection</u>

"Poster session should held on second day to increase the understanding of participants."

"High quality speakers is critical."

"Increase # of high quality "outside" speakers from important industry/applications up to 20-25% of total"

"Talks on more focused topics"

"More time for session-wide open discussion (panel)"

"More time for expert panel discussion (although it is sometimes hard to get audience participation)"

"Would be interesting to get [participation from?] folks interested in heat transfer but not directly working on it to broaden the horizons."

"The scientific quality of the presentations was excellent and it was refreshing to hear the talks because there were so many new insights and approaches. There were lots of new faces among the participants, especially on the Japanese side, which was refreshing indeed."

"Moving forward, my only suggestion is to broaden the topics a bit more and embrace a few other transport and conversion phenomena that have shown Moore's law kind of techno-economic trends with significant societal impact. Examples include ionic transport and reactions in electrochemical systems (e.g. batteries), mass transport and chemical reactions in nanostructures (e.g. natural gas in shale rock), etc. ... there is heat everywhere. I would add there are molecules and chemical reactions everywhere too. Finally, a feedback loop between people in industry and academia that would lead to educating each other, and leveraging of expertise and strengths would be good."

<u>Timing and Breaks</u>

"Slightly less rush and more breaks, so that schedule is respected."

"Break 15 mins, not 10 mins"

"Longer breaks will foster discussion, should be 15 mins, 20 mins is better"

"Need more time to informal discussion (reduce # of talks by 10-15%)"

"Maybe longer breaks"

<u>General / Other</u>

"It [would be better to have] numbering on abstracts. It [would be] easier to find out the contents. For example, first day A10, A11 etc."

"Bad habit of Japan side, they liked to get gathered during the seminar. To improve, from next time, organizers should more explicitly encourage both sides to mix up, especially in dinner in banquet. But I honestly think that this should be mostly the job of Japan side organizers. In the last seminar in Japan (7th), there was this kind of encouragement from the organizers, and I felt it had partially worked. I had enjoyed in the mixed-up atmosphere of the 7th having communicated with several young researchers of US side, but I also have noticed that this was the matter of the attitude of myself (or attitude of each participant, not the attitude of the organizers)."

"Too many meetings on the same topic. I see the same talks multiple times"

"Current way of evolution seems really great. I'm getting to know more and more people at each time, yet keeping contacts with the familiar people."

"This was a great experience"

"Fantastic meeting as is."

"Alaska" [as a possible location?]

Part II: Research

*4) Major Accomplishments in Your Field. Thinking **back** 12 years (i.e., the time of the 2002 US-Japan meeting), list 1 to 3 of the most important advances in your field. This could be in theory, experiment, and/or application. (Order does not matter.)*

Responses, grouped loosely into themes. Here we lump all respondents together (no distinction between professional researchers and students+postdocs).

1st Principles Modeling

1st principles modeling of thermal conductivity.

1st principles k

phonon properties and k from 1st principle

Thermal conductivity calculation based on 1st principle

predicting thermal conductivity from 1st principles

1st principle k prediction

advancement of 1st principles simulation techniques

1st principle calculation of phonon thermal cond.

Use of DFPT to get 3-phonon scattering time

Other Modeling

New computational tech. such as 1st principles, MD

molecular dynamics of heat conduction in nanomaterials

Better understanding of phonon transport

Measurements Techniques (Solids / Conduction): TDTR

TDTR

Development of TDTR as a major tool for measuring thermal conductivity

Develop and analyse in thermal metrology (e.g. TDTR/FDTR individual nanostructure measurement etc.)

New thermal measurement tech., such as TDTR

TDTR implementation/data analysis

wide distribution of pump-probe thermometry tech

<u>Measurements Techniques (Solids / Conduction): Other</u>

Suspended device for measuring 1D and 2D nanostructures.

Thermal metrology improvements ability to get conductivity and or conductance for nanomaterials

thermal characterization techs. (measuring temp. with great [?])

measurement of nanostructure

Measurement of k of nano materials

New technique to probe nanoscale thermal transport

Instrumentation advances in measuring thermal conductivity and phonon properties

nanoscale thermal measurement: thin film/ nanowire/ thermometer

Development of fs x-ray scattering from phonons.

Thermal scanning probe techs.

<u>MEMS & Nanodevices</u>

MEMS sensors

single nanoscale Pt covered by Silica

Molecular electronics

<u>Radiation</u>

Specific control of near field radiation

Near field radiation HT

Near field radiation HT

Near field radiation experiment

Thermal radiation

<u>Phonons: Mean Free Paths</u>

phonon MFP spectroscopy

identify role of broad phonon spectrum in thermal transport(theory and experiment) *phonon MFP spectroscopy*

Emergence of MFP spectroscopy

MFP understanding

Experiments on the phonon MFP

emphasis on broadband nature of thermal transport by phonons

Phonons: Coherence

Evidence of coherent phonon transport [recent experiment]

Coherent ballistic transport in SLs [2 recent experiments]

Phonons: Other

Phonon control(e.g. coherent in superlattice, thermal rectification, MFP spectroscopy etc.)

Understanding of length scale associated with phonon transport through theory, computational, and experiment approaches

Materials: Thermoelectrics

new approaches to improve zT

bulk nanostructured materials for TE energy conversion

zT=1 before, 2.6 now (but no commercial/social impact yet)

zT enhancement by nanostructure

nanostructuring of thermoelectric materials

The idea that nanostructuring can improve TE efficiency

Thermoelectrics.

Spin Seebeck effect: thermoelectric

Materials: Other

Identification of new 2D, 1D, 0D materials and confinement of what they can and can't do for heat transfer applications

Increasing refocus on soft materials

Graphene

<u>Other / General</u>

thermal interfaces

highly improved understanding of heat transfer at interfaces, including measurement and modelling

thermal rectifiers

Discovery of high thermoionic generation in solids

heat conduction

ultra low thermal conductivity

"Diffusion process" of the research interests and the tools between US-Japan that should have benefited both sides.

*5) Grand Challenges in Your Field. Thinking **ahead** 12 years (i.e. the time of the 2026 US-Japan meeting), list 1 to 3 grand challenges on the horizon which you think your field might be able to address. (Order does not matter.)*

Responses, grouped loosely into themes. Here we lump all respondents together (no distinction between professional researchers and students+postdocs).

Modeling

1st principles [modeling] of complex materials

use latest advances in 1st principle to develop novel analytical theory that can help obtain intuition (e.g. beyond Callaway, role of different harmonic/anharmonic terms& phonon branches on thermal transport)

model complex structures from atomic simulations

Multi-scale, multiphysics modeling tools

accurate rapid simulation tools in transition region

Boundary Conductance: predictive modeling without free parameters: agreement between models + experiments

Unified theory for transport in non-crystalline materials

Experimental

measure T of single atoms

measurement of small scale or short time temperature

Measurement of nanoscale liquid/gas interface

3D thermal mapping inside solid objects

Applications: Microelectronics Related

Mobile electronics power management

Development of low voltage logic switch

molecular memory

chip cooling: heat dissipation on chips with further decreasing the chip size

Engineer 2D materials for thermal spreading application

Applications: Scale-Up of Nano

scale up of nano thermal solutions

scaling of individual nanostructures/ properties into reproducible, macroscopic, or device level function (e.g. CNTs, etc.)

realization of nanoscale transport physics/application into commercial devices

directly translating the basic science & theoretical work into practical tech. & engineering solutions.

<u>Applications: Energy Related</u>

handing waste heat efficiently

large scale use of waste heat

reduce significant amount of waste heat in convert energy infrastructure (power plant, engines, electronic etc.)

Energy efficiency increase; consumption decrease; waste decrease; unnecessary heat decrease

energy efficiency + generation

thermal energy conversion: improved approaches

energy conversion at atomic length

energy use from sun light

Energy and power application: design and technology enabling low cost, reliable, safe, compact, flexible energy conversion and power generation

<u>Applications: General / Other</u>

Nano-bio-thermal interfaces

Thermal phenomena in biological systems

Water consumption decrease; urban design

<u>Materials: Thermoelectrics</u>

high ZT =4

Twice the current thermoelectric zT

very efficient TE

application of complex oxides an energy conversion technologies(e.g. Perovskites)

achieving breakthroughs in thermoelectric energy efficiency

translating advances in TE materials & physics to devices and systems

TE device integration

Enhanced Thermal Functionality

thermal switches

thermal rectification

materials with tunable thermal properties

Enhancing the thermal functionality of materials

Thermal Conductivity

push the extreme of thermal conduction in materials

Extreme properties materials: super conductor, super-insulator, and incorporation in real devices and products

Best thermal conductors beyond diamond

Fundamental Issues in Materials / Physics (Modeling and/or Experiment)

conclusively establish link between interface conductance and local defect density

manipulate phonons beyond the current approaches limited by scattering and anharmonicity

complete picture of phonon transport

Understanding and manipulating thermal conductivity of materials at sub-phonon wavelength scales.

phonon as waves?

understanding microscopic e-ph and ph-ph interactions

electron phonon- coupling in bulk, film, and cross interfaces

isolate energy & charge transport

inorganic-organic hybrid materials