Introduction to Algebraic Topology at BIMSA Close Remarks Summer School on Chromatic Homotopy Theory and Higher (Infinity-Categorical) Algebra August 15 - 26, 2022

### Jie Wu

#### Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

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Full name of BIMSA: Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

It is a newly launched **applied math center of Yau** from June 2020, linking to the Yau center at Tsinghua, connecting to other Yau centers.

Currently, BIMSA has over 100 researchers from postdocs to all level of regular positions.

Hiring of BIMSA is available with aiming to the final size of around 300 people.

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### President of BIMSA is Shing-Tung Yau

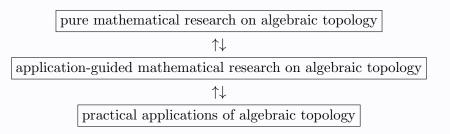


Currently, there are 11 people who hold professorship positions titled Research Fellow, including



• Nicolai Reshetikhin

## Research Structure of Algebraic Topology at BIMSA



### pure mathematical research on algebraic topology

- homotopy theory
- configuration spaces, braid groups, topological complexity
- homotopy aspects of knot theory
- homotopy patterns in group theory
- research interests will be extended when more people come.

# application-guided mathematical research on algebraic topology

- Topological structures of the networks given by graphs/digraphs/quivers, aiming to **exploring new topological features of data**.
  - digraph homotopy and path homology.
  - hypergraph homology.
  - topological approaches to data beyond classical persistent homology.
- Evolutionary system of topological structures, aiming to
  - evolutionary dynamics of data
  - fundamental laws of biology

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### practical application of algebraic topology

- Jelena Grbic, Jie Wu, Kelin Xia and Guowei Wei, "Aspects of topological approaches for data science." Foundations of Data Science, 4(2), 165 (2022).
- Xiang Liu, Huitao Feng, Jie Wu, and Kelin Xia, "Dowker complex based machine learning (DCML) models for protein-ligand binding affinity prediction." PLOS Computational Biology, 18(4), e1009943 (2022)
- Xiang Liu, Xiangjun Wang, Jie Wu, and Kelin Xia, "Hypergraph based persistent cohomology (HPC) for molecular representations in drug design." Briefings In Bioinformatics, 22 (5), bbaa411 (2021)

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- Jürgen Jost, March 10, 2022.
- Guo-Wei Wei, March 24, 2022.
- Gunnar Carlsson, April 21, 2022.
- Victor Buchstaber, April 28, 2022
- Konstantin Mischaikow, May 5, 2022.
- Herbert Edelsbrunner, May 26, 2022.

# Digraph homotopy and path homology, the notion recently introduced by Yau.

Path homology would be good and better in TDA (topological data analysis), particularly, for networks given by digraphs/quivers.

Bio-network, brain network, interactions between microbiomes and many others have directions.

Evolutionary system of spaces with dependent/correlated multi-parameters might be modeled by digraph/quiver with assigning a space as a weight to each node (i.e., representation of digraph/quiver in topological spaces).

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Mathematical biology

### Strategic goal: fundamental laws of biology

My dream: homotopy theory would become a proper descriptor for the structure and evolutionary dynamics of multi-layered complex networks, from molecules to cells to organs, which leads to life.

## Connections with other people at BIMSA

- A partner of the lab of Big Data and AI at BIMSA.
  - Working together with statisticians on applications in BIG Data.
  - Statisticians work out proper meaningful model of (di-)graphs from practical problems, and we do mathematics for exploring structures of data.
- digital economics at BIMSA.
- quantum information at BIMSA.

Thank You for attending this excellent program!

Thanks for the lecturers and all people contributing to the success!