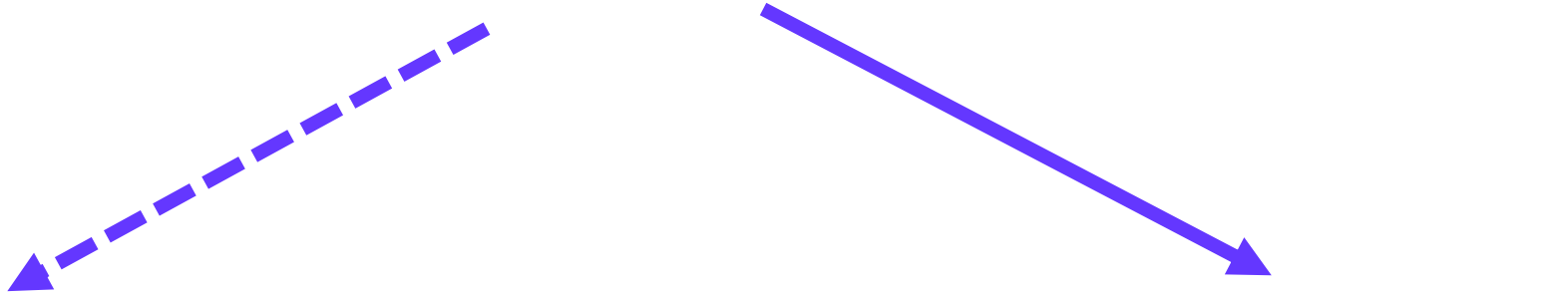
INTERACTING WITH HADWARE

Bridge the Gap

- Between Bloqade and hardware!

$$\frac{H}{\hbar} = \sum_i \frac{\Omega(t)}{2}\left(e^{i\phi(t)}|g_i\rangle\langle r_i| + e^{-i\phi(t)}|r_i\rangle\langle g_i|\right) - \sum_i \Delta_i(t) n_i + \sum_{i<j} V_{ij} n_i n_j$$



```
BloqadeSchema.submit_to_braket
```

```
emulate!(prob)
```

Learning Objectives

By the end of this class, you will be able to:

- **Describe** the Bloqade to Hardware pipeline
- **Differentiate** transformation and validation functions to work within Hardware Constraints
- **Design, Submit, and Retrieve** Hamiltonians for Hardware

Start with a question:

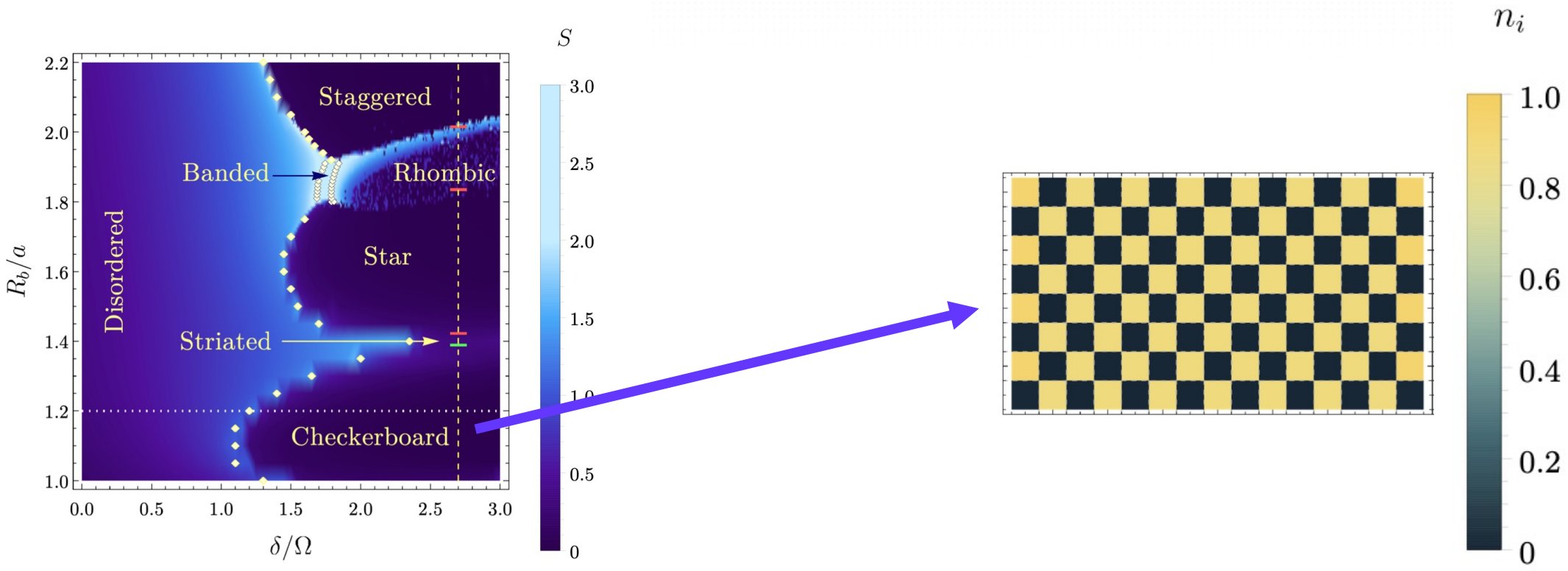
- If you got here after going through sessions I and II, you already know how to operate Bloqade for doing emulations.
  - Activity: Think-share
    - What steps would you claim need to happen in order to submit an algorithm you developed in Bloqade to run in a real quantum computer?

Big Picture

- 1. **Define** your problem
  - If you can, emulate to verify algorithm!
- 2. **Transform** to Hardware
- 3. **Validate**
- 4. **Tweak** problem (if necessary)
- 5. **Submit**!
- 6. **Retrieve** data

Start With A Problem

- Attempt to recreate **2D Checkerboard Phase**



Let's revise on Bloqade!

R. Samajdar et al., Phys. Rev. Lett. 124, 103601 (2020)

transform and *validate*: why?

Make sure your algorithm will run BEFORE submission to hardware

transform

- Hardware has some important limitations to consider

Activity: name some hardware constraints you learned of in previous sessions

  - Atoms have a minimum distance they can be placed next to each other
  - Have finite-valued Rabi, Detunings, and Phase
    - Final waveforms on hardware must be piecewise Linear/Constant (discretization necessary)
    - Your slope or "slew rate" cannot exceed certain maximums
  - Minimum time resolution to consider (smallest increment of time you can define)

Find Hardware Constraints documented Here:
https://queracomputing.github.io/Bloqade.jl/dev/capabilities/

Global Rydberg Values

Capability	Field	Value
Rydberg Interaction Constant	`c6_coefficient`	5.42×10^{6} rad/µs × µm^{6}
Minimum Rabi Frequency	`rabi_frequency_min`	0.00 rad/µs
Maximum Rabi Frequency	`rabi_frequency_max`	15.8 rad/µs
Rabi Frequency Resolution	`rabi_frequency_resolution`	0.0004 rad/µs
Maximum Rabi Frequency Slew Rate	`rabi_frequency_slew_rate_max`	250.0 rad/µs^{2}
Minimum Detuning	`detuning_min`	-125.0 rad/µs
Maximum Detuning	`detuning_max`	125.0 rad/µs
Detuning Resolution	`detuning_resolution`	2.0×10^{-7} rad/µs
Maximum Detuning Slew Rate	`detuning_slew_rate_max`	2500.0 rad/µs^{2}
Minimum Phase	`phase_min`	-99.0 rad

Objective of *transform*

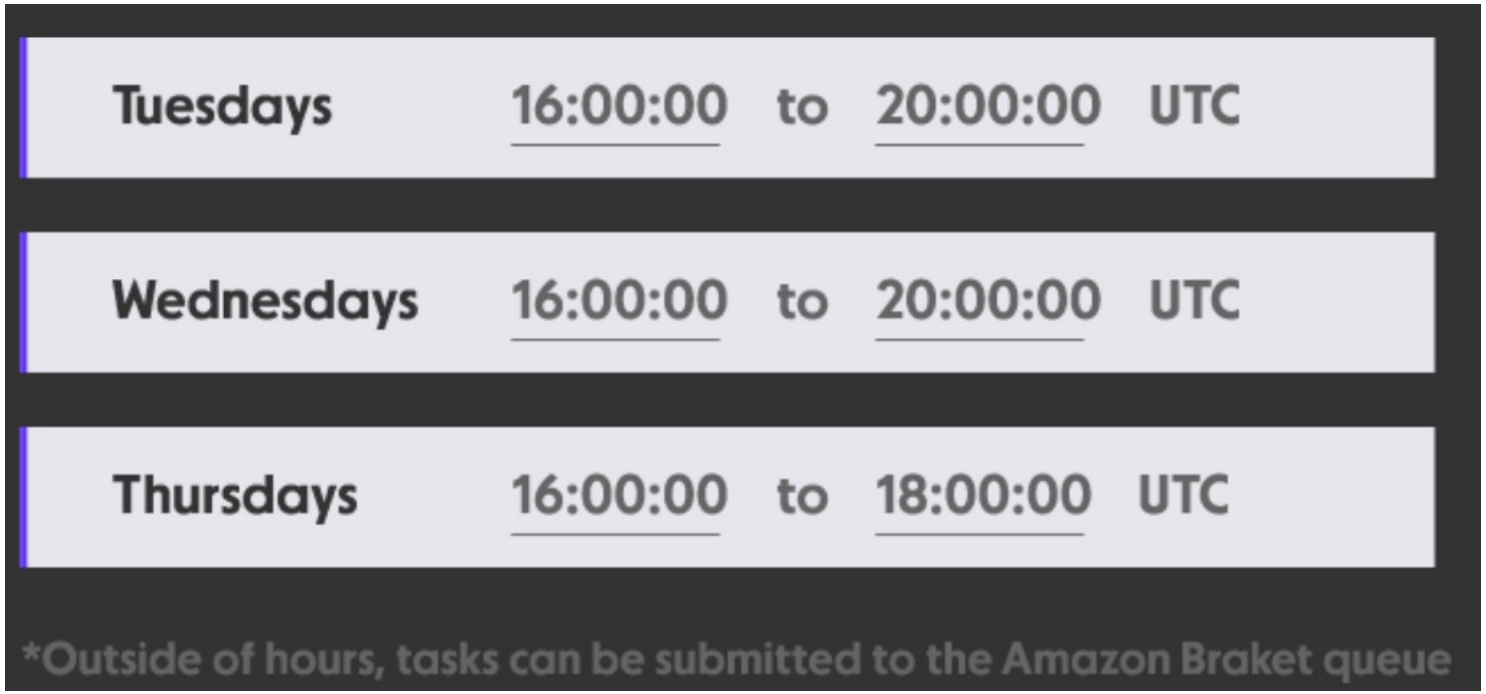
- **MAXIMIZE** your flexibility to design algorithms
- **MINIMIZE** the need to bookkeep all constraints by hand

validate

- Occasionally, there are certain things that can't be automatically transformed
  - Most commonly with atom position constraints
- Require some form of user intervention, this is where validation is necessary!
- Treatable as a *catch-all* for any incompatible Hamiltonians

Submitting

- If the Hamiltonian passes Validation, you'll need your AWS Credentials
- Upon submission, may need to wait a bit as tasks go on a queue that the machine will consume from when it's open



Retrieval

- Heavy lifting done by Braket.jl
- Results can be saved in HDF5-Compatible format or JSON for usage inside Python
  - JSON is the friendlier format!

Summary

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