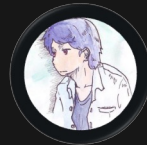


# Qiskit Advocate Mentorship Program

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#20

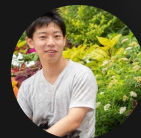
Implement new features and improve documentation in Operators



Mentor:

Ikko Hamamura

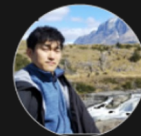
Mentees:



Daiki  
Murata



Yuma  
Nakamura



Kazumasa  
Umezawa

# Overloading `@` for Operator class

## Motivation

To make easier to read the code, overloading `@` and make it work the same as *Operator.dot()*

If you want to get the right multiplied operator,

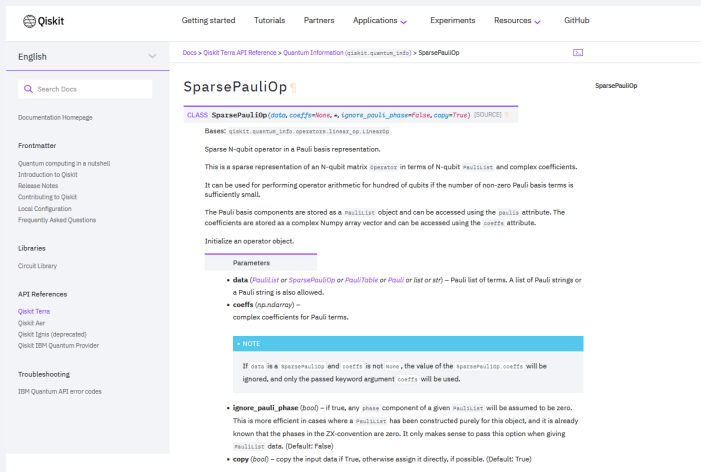
**As is : `a.dot(b)`**

**To be : `a @ b`**

# Implement argsort and sort method to SparsePauliOp

## 【SparsePauliOp】

This is a sparse representation of an N-qubit matrix Operator in terms of N-qubit PauliList and complex coefficients.



## 【Motivation】

PauliList has argsort() method and sort() method .

We need these features in SparsePauliOp .

## 【Doing】

1. Understanding PauliList and SparsePauliOp
2. Implementing SparsePauliOp.argsort() and SparsePauliOp.sort()

## 【ToDo】

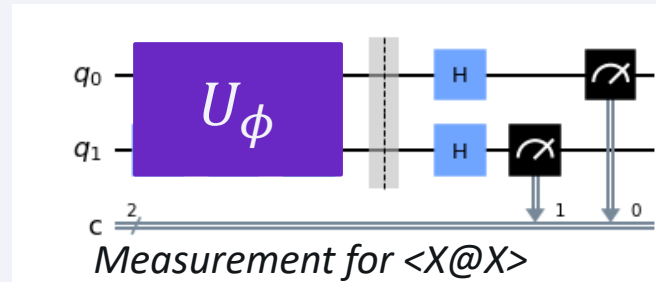
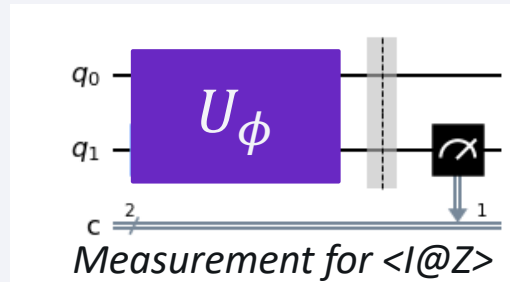
1. Sending a pull request.
2. Development of other issues.

# Efficient Evaluation of Observable

## Background

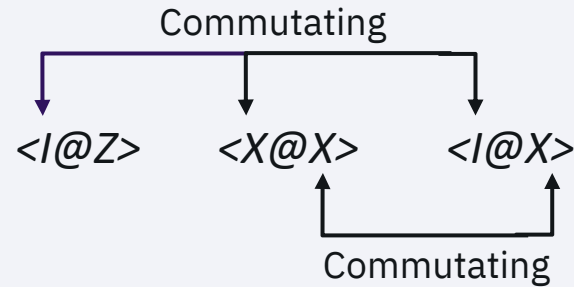
Evaluation of observable requires multiple measurement,  
where commuting observable can be evaluated simultaneously (grouping).

*e.g.  $H = \langle I@Z \rangle + \langle X@X \rangle + \langle I@X \rangle$  can be evaluated only by calculating  $\langle I@Z \rangle$  and  $\langle X@X \rangle$*



## Existing Algorithm

qubit-wide commutation is inspected



# Efficient Evaluation of Observable

## New Algorithm

General commuting rule is employed

e.g.  $\langle X@X \rangle$  and  $\langle Y@Y \rangle$  are commuting but qubit-wise commuting rule cannot detect.

## Impact

Grouping observable reduce the number of required measurement.

Its reduction contributes to **faster** VQE.

Molecule	Transformation	Number of Groups		
		No-grouping	Qubit-wide Commutation	General Commutation
LiH	JW	631	136	35
	Parity		165	35
	BK		211	35
BeH <sub>2</sub>	JW	1150	215	58
	Parity		323	58
	BK		341	58
H <sub>2</sub> O	JW	1858	380	84
	Parity		495	82
	BK		515	82
NH <sub>3</sub>	JW	4973	1052	117
	Parity		1091	115
	BK		1086	115
HCl	JW	4427	906	110
	Parity		1098	112
	BK		1434	112

## Pull Request

→ <https://github.com/Qiskit/qiskit-terra/pull/7874>

- We are aiming to contribute `Qiskit.quantum_info`
  - Multiply operator method [`a.dot(b)` → `a @ b`]
  - Sort Pauli operators
  - Grouping Pauli operator for simultaneous measurement
- Our contributions will appear on github pull-request soon!!

Thank you