Option Pricing in Finance

Mil’HaQ Fest 2025

Mila

Autorité des marchés financiers

QUANDELA

IBM

The teams can choose between two tracks :

QISKIT 2025 2025 FALL FEST

Track 1 : Quantum random walk for put and call options pricing;

Track 2 : Swaptions option pricing with quantum machine learning.

The teams can also choose one of two quantum computing frameworks :

a) qiskit of **IBM**;

b) perceval/merlin of Quandela.

Calculations can be performed on :

1. a simulator (i. e. classical computer);

2. real quantum computer.

Track 1 : Quantum random walk for put and call options

Track 1 : Quantum random walk for put and call options

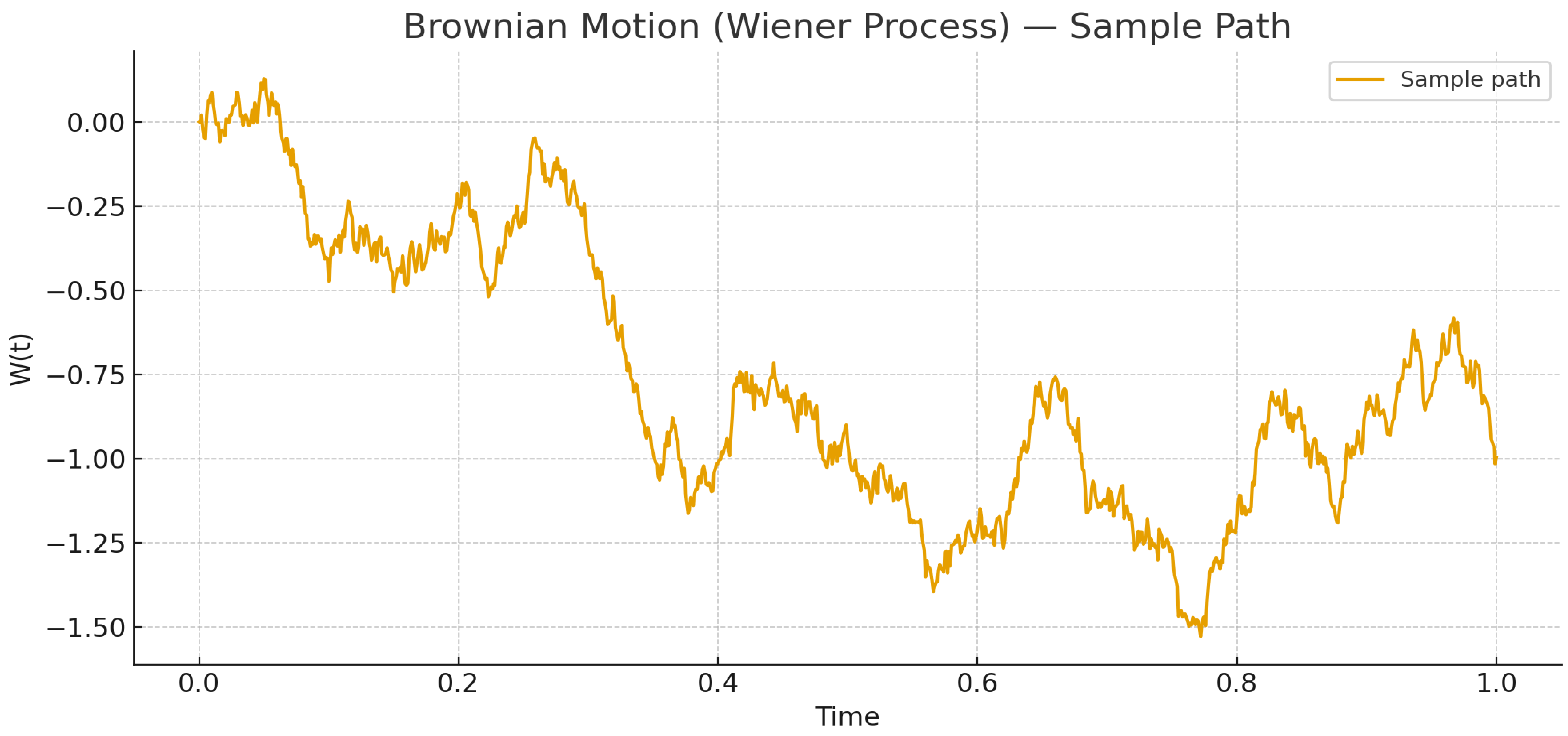
- The goal of the team is to **calculate the price of put or call options** using a quantum random walk.

- In this track, we use the Black-Scholes model to calculate option prices with **constant interest rate and volatility**.

- The calculated option prices can be **approximate**.

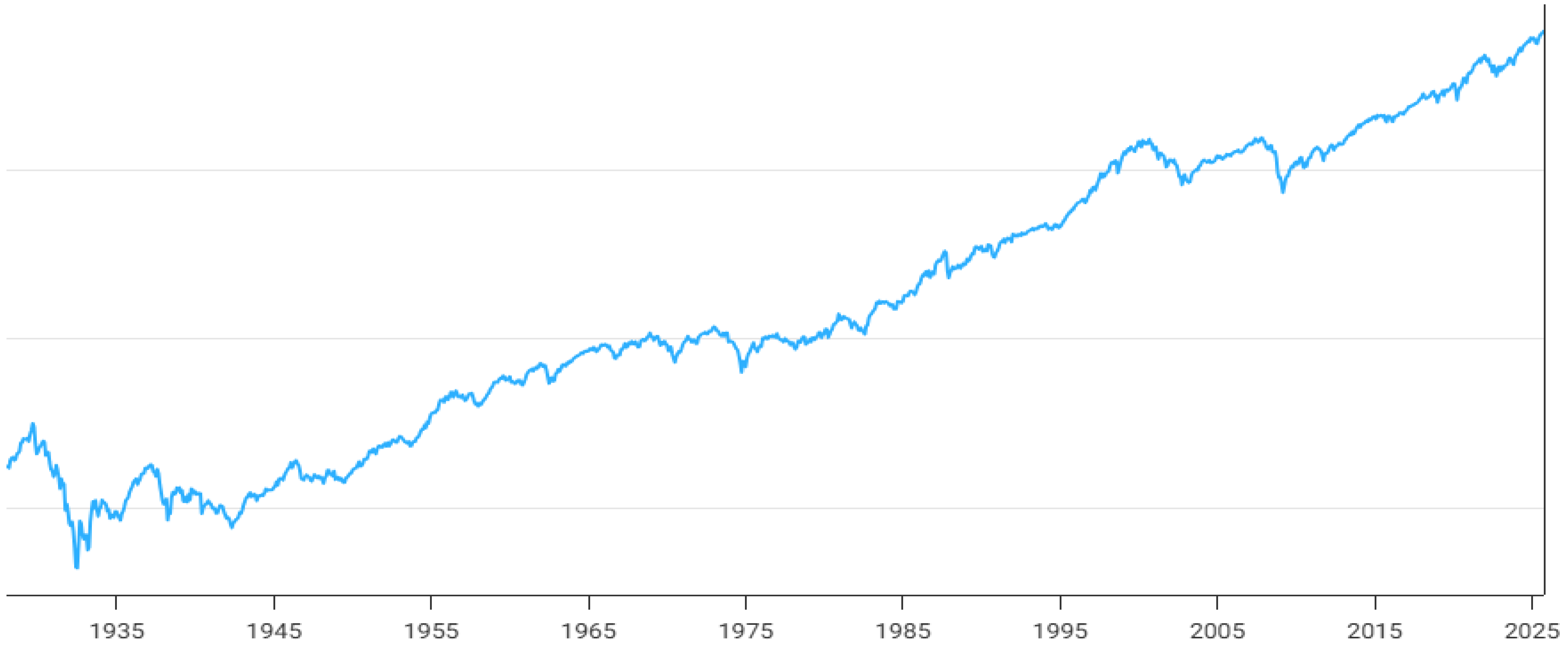
Track 1 : Quantum random walk for put and call options

Random walk



Track 1 : Quantum random walk for put and call options

S&P500 Return



See https://www.macrotrends.net/2324/sp-500-historical-chart-data

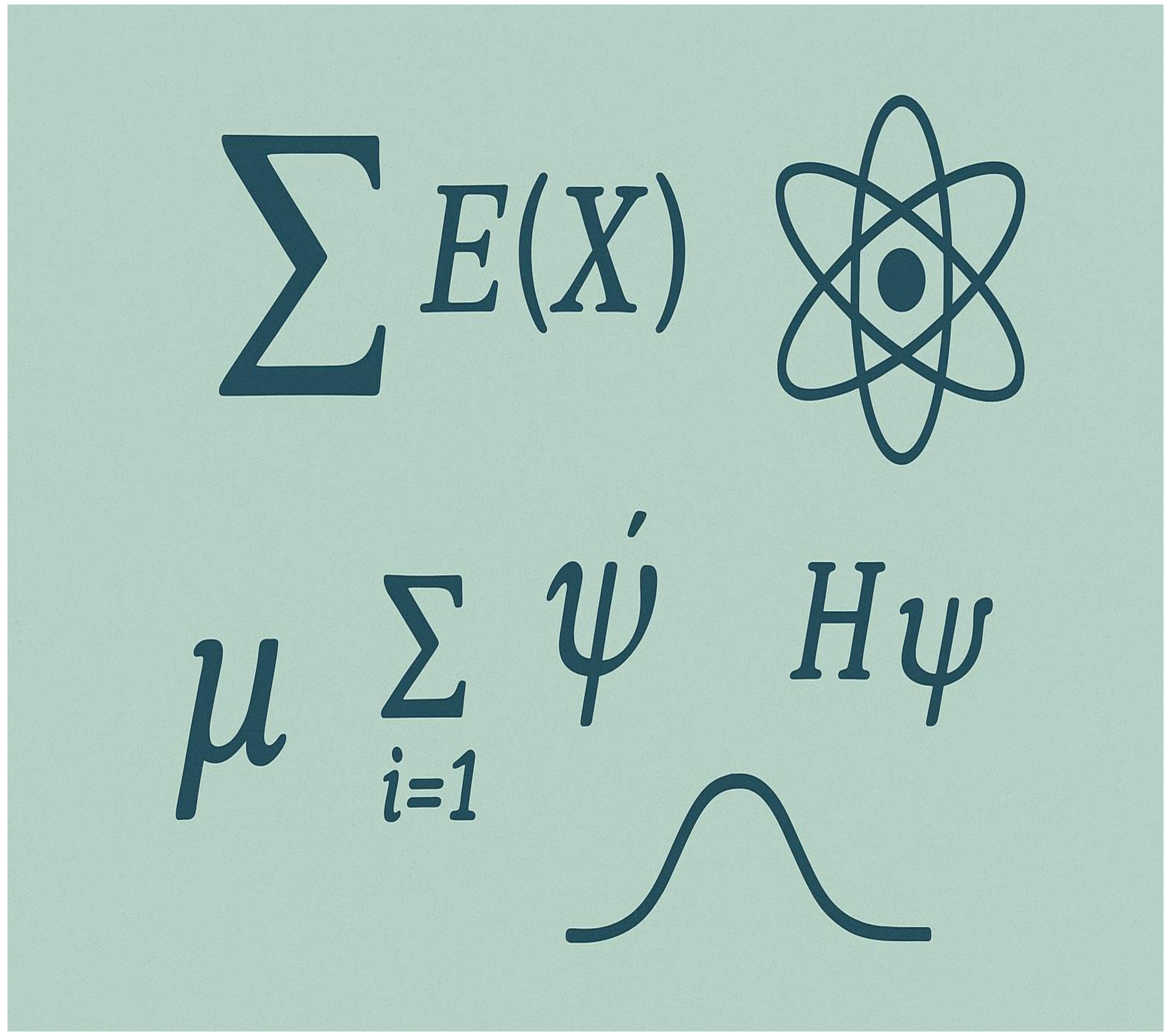
Track 1 : Quantum random walk for put and call options

- A call option is an option to buy an asset at a specific price at a specific point in time.

- A put option is an option to sell an asset at a specific price at a specific point in time.

- The specific price is the strike price.

- *For example, we can have a call option to buy one share of the S&P500 at 10000$ in 3 months.*

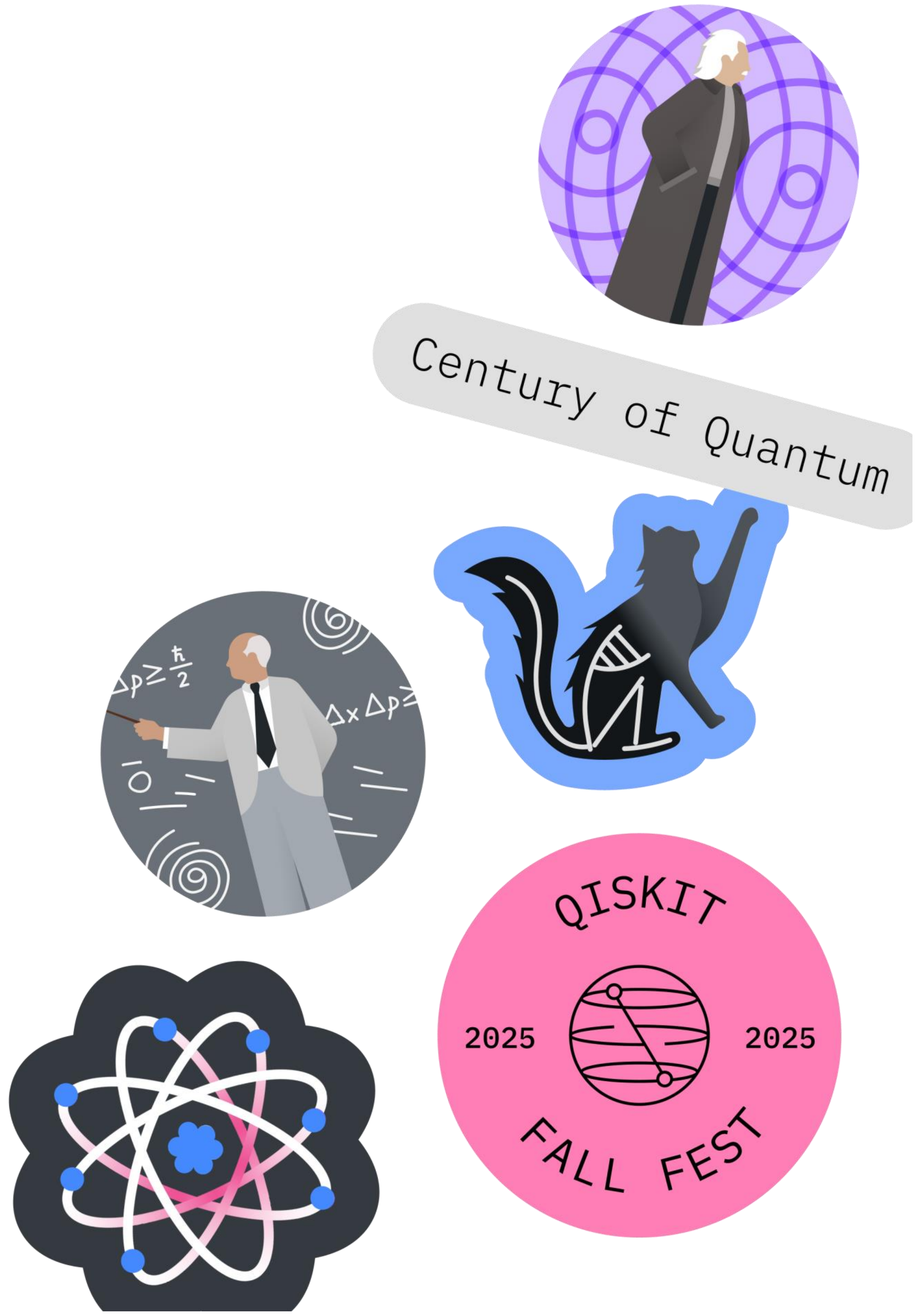


Track 1 : Quantum random walk for put and call options

- The analytical formula to calculate put and call options for the Black-Scholes model will be provided;

- A code for a classical computer will be provided to calculate the exact price of put and call options for the Black-Scholes model;

- Parameters will be provided to calculate the price of the options (i. e. strike price, asset price, interest rate, volatility, time to maturity, etc.);



Track 1 : Quantum random walk for put and call options

- The goal of the students is to obtain an approximate price for put and call options using a quantum random walk for a given set of parameters.

- We will not provide a dataset of option prices for track 1.

Track 1 : Quantum random walk for put and call options

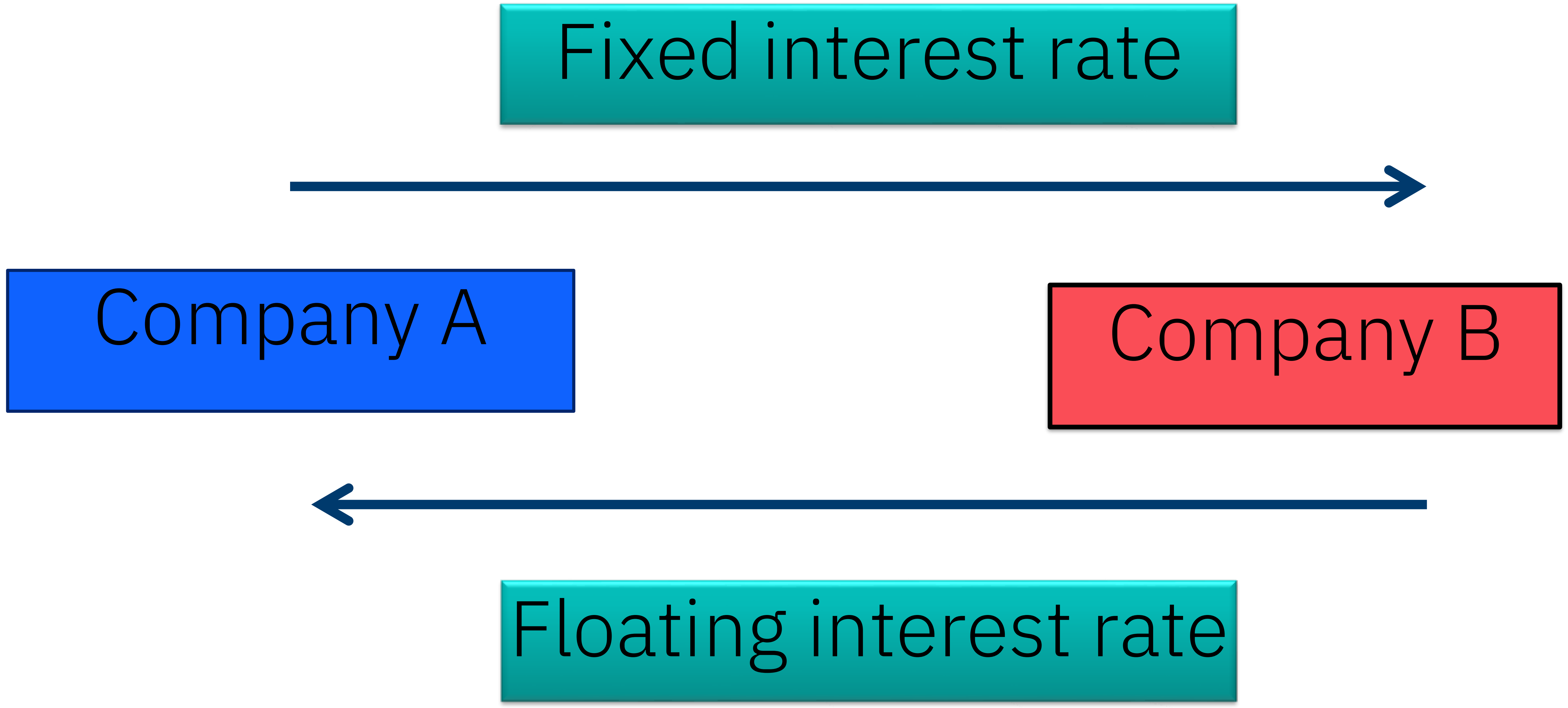
r	K	S_0	σ	T	Put Value Black-Scholes Model	Call Value Black-Scholes Model
0,01	1	1	0,05	1	??	??
0,02	0,85	1,1	0,15	2	??	??
0,03	1,15	0,9	0,2	3	??	??
0,04	0,9	0,95	0,1	4	??	??
0,05	1,1	1,05	0,125	5	??	??

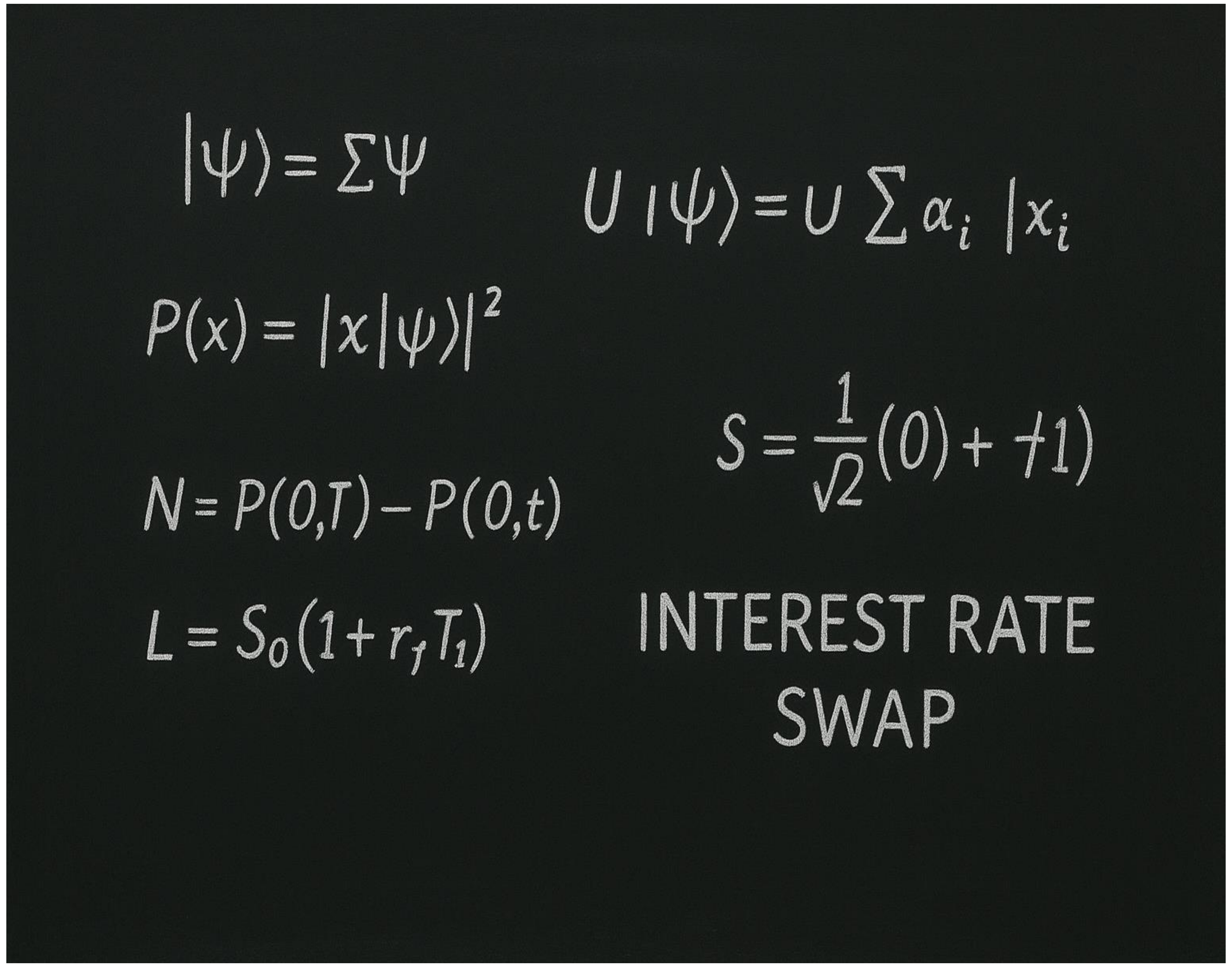
Track 2 : Swaptions option pricing with quantum machine learning

QISKIT 2025 2025 FALL FEST

Track 2 : Swaptions option pricing with quantum machine learning

An interest rate swap is a contract for which one party will pay a fixed interest rate and the other will pay a floating interest rate.



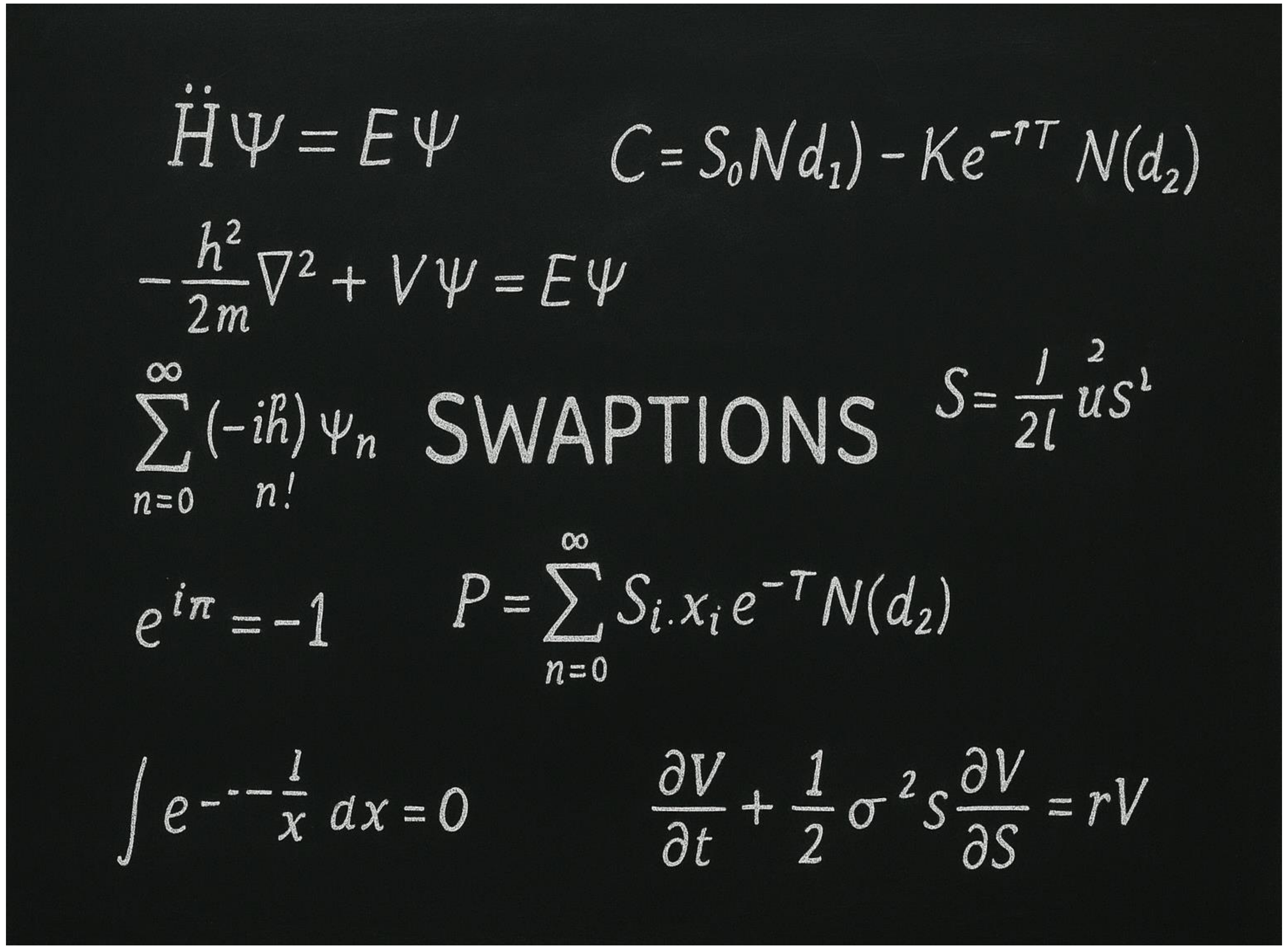


Track 2 : Swaptions option pricing with quantum machine learning

A synthetic dataset of swaptions prices was generated with a **realistic** model and will be provided to the teams;

The goal of the teams is to use quantum machine learning models to :

- 🔎 **goal 1** : predict the values of missing data in the dataset;
- 🔭 **goal 2** : predict the future swaptions prices for the next two weeks.



Track 2 : Swaptions option pricing with quantum machine learning

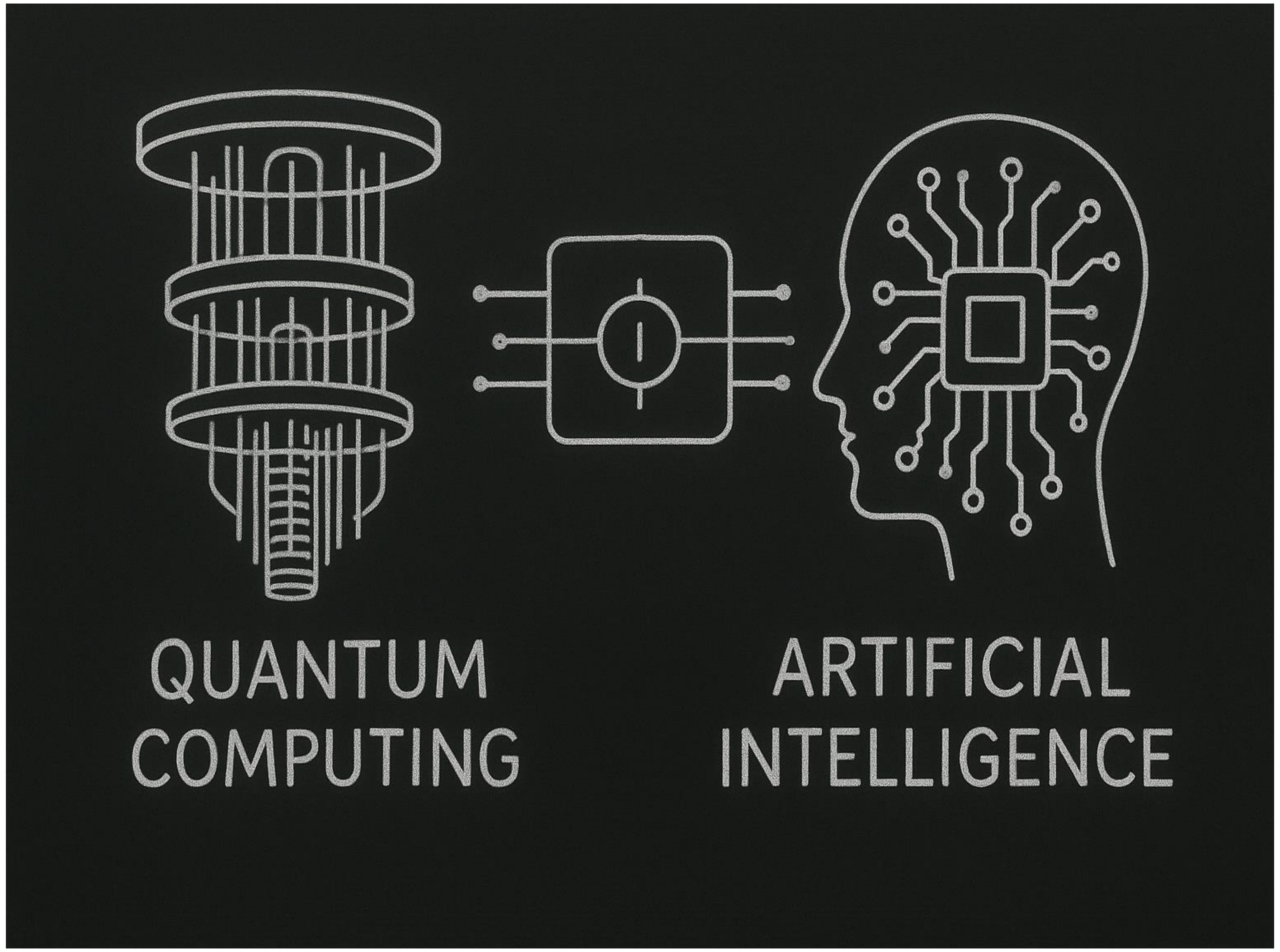
- The options on interest rate swaps (i. e. swaptions) have a tenor and a maturity.
- The maturity is the moment at which an option can be exercised.
- The tenor is the length of time of the interest rate swap payments.
- Main task : ***predict future data*** and predicting missing data is optional

Tenor : 10; Maturity : 30	Tenor : 15; Maturity : 30	Tenor : 20; Maturity : 30	Tenor : 25; Maturity : 30	Tenor : 30; Maturity : 30	Date
0,32239296	0,34585919	0,35916232	0,34667048	0,33767007	01-01-2050
0,3281438	Missing data !!	0,36519689	0,35099282	0,3408224	01-02-2050
0,32543597	0,34891453	0,36223568	Missing data !!	0,33902681	01-03-2050
0,32977101	0,3532459	0,36610005	0,3514044	0,34046496	01-05-2050
Future data	Future data	Future data	Future data	Future data	01-06-2050
Future data	Future data	Future data	Future data	Future data	01-08-2050

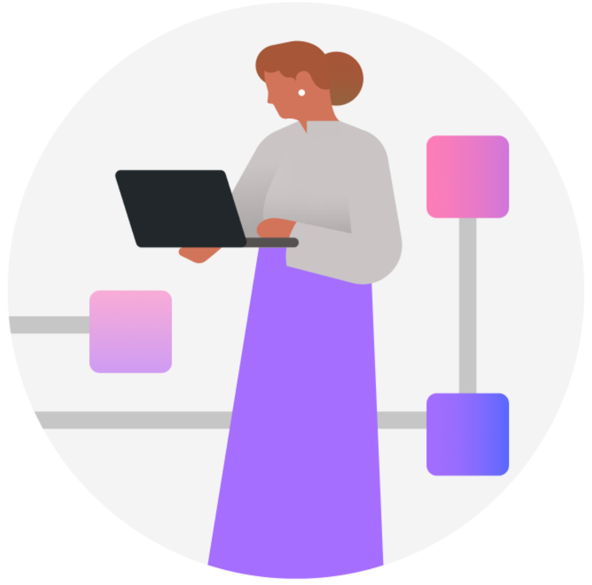
Track 2 : Swaptions option pricing with quantum machine learning

- The students can use quantum machine learning techniques such as quantum reservoir or other techniques.

- The goal of the students is to predict the value of missing data and predict future values of swaptions prices by training a quantum machine learning model.



Track 2 : Swaptions option pricing with quantum machine learning



- Encode input window (e.g., past 20 trading days of features) into an optical/quantum reservoir.
- Collect reservoir states (e.g., photon-count histograms / mode quadratures / qubit expectation values).
- Train linear readout (ridge/Lasso) to: (a) impute gaps; (b) predict 1–10 day horizon prices. Use walk-forward, compare to gradient boosted trees, and small LSTMs.
- Report accuracy and memory capacity vs. reservoir parameters (depth, nonlinearity, noise).

Files to submit at the end of the Hackathon

Files to submit at the end of the Hackathon

Track 1 : Quantum Random Walk

- Excel Template filled with results;
- Python code;

Track 2 : Quantum Machine Learning

- Excel Template filled with results;
- Python code;

Criteria to determine the winner

Criteria to determine the winner

Technical aspects :

- How accurate is the model?
- How complex is the quantum algorithm?
- Can the architecture serve users at a reasonable scale?
- Etc.

Originality and uniqueness :

- How unique is this project compared to others?
- Did the team attempt something new or difficult?

Criteria to determine the winner

Usefulness and complexity :

- How useful is the project and how well-designed is it?
- How functional is it at the time of judging?

Presentation :

- How well did the team present their project?
- Were they able to explain their decision?