# ZX-Calculus
# [M2 QMI] Syllabus

## Course Description

This course provides a graphical approach to represent and study quantum information and computation. After exploring general features of quantum information in a graphical yet formal way, we introduce the more specific ZX-calculus, that can be used to represent and manipulate states and operators at an atomic level. We will show some important results about quantum information in this setting, and will further demonstrate its use in applications ranging from verification to simulation.

## Prerequisites

- Linear algebra
- Basics of quantum information

## Course Objectives

- Learn the basics of diagrammatic quantum computation
- Perform manipulations on ZX-diagrams
- Explore applications of ZX-calculus (MBQC, Gottesman-Knill theorem, verification, simulation, ...)

## Topics Covered

### Diagrammatic Approach to Quantum Information & Computing

- String diagrams

- Compositions and tensor products
- Transpose, dagger, map-state duality
- Partial trace and channels
- CPM construction

### Introduction to ZX-Calculus

- Definition of the generators – flexsymmetry
- Circuit-to-ZX translation
- Universality
- Stabiliser equational theory – manipulations
- Normal form and reduction in the H-free 0-fragment

### Advanced ZX-Calculus

- Graph states, pivoting, local complementation
- Normal form and reduction in stabiliser fragment (Gottesman-Knill theorem)
- Euler angles
- Extension to channels
- Extension to scalable notation

### Applications

- Verification (teleportation, superdense coding, Bernstein-Vazirani, Deutsch-Jozsa, Simon, pseudo-telepathy games, BB84?, ...)
- MBQC
- Error correction (stabiliser codes?, surface code & lattice surgery, ...)
- Simulation in Clifford+T
- [TBC] T-count reduction in circuits
- [TBC] Manipulations with PyZX/QuiZX

## Evaluation

- Exam: 100%