My Beloved PhD: Hierarchical Self-Assembly

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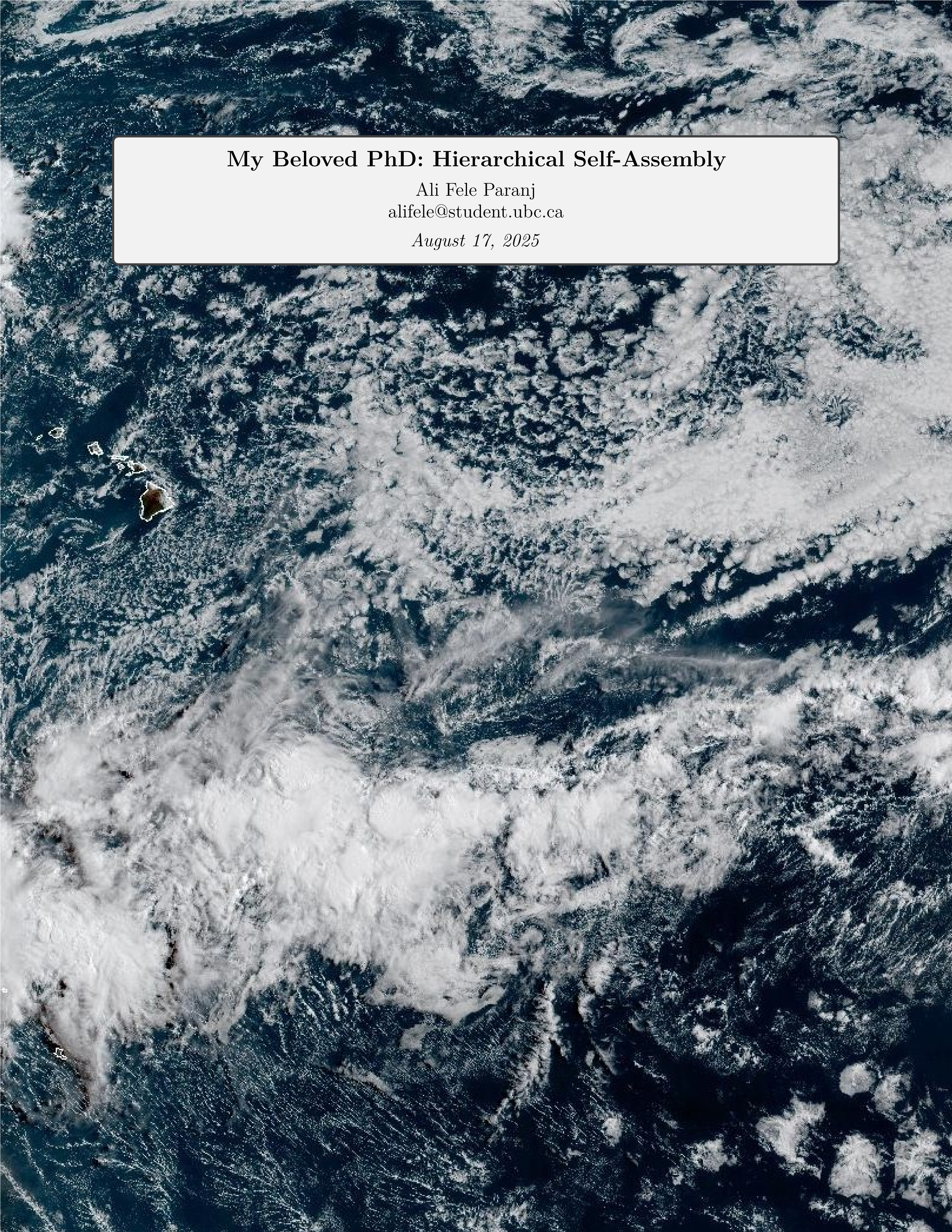

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Discrete Mathematics

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Combinatorics

1.1 Basic Review

Summary 1.1 One possible interpretation for the formula of n-choose-k is the following. Let $A = \{a, b, c, d, e\}$, and assume we want to choose 2 elements from the set. Fix some ordering for the elements in the set and assume each selection is represented by a 5-tuple, where each index specifies if that elements in the set is chosen. For instance $(1, 1, 0, 0, 0)$ corresponds to the choice $\{a, b\}$. So the total number of such choices will be total number of ways that we can arrange two 1's and three 0's, which is

$$\frac{5!}{2!3!}.$$

So in general we can write

$$\frac{n!}{(n-k)!k!}.$$

1.2 Solved Problems

■ **Problem 1.1** What is the number of choosing k objects out of n, where order does not matter, but repetitions are allows.

Solution This problem is very similar to the one in the thermal physics bo by Schroeder when studying the number of possible ways to distribute Q units of energy in N Einstein solids.

Let's consider a concrete example where we want to choose 3 objects from $\{a, b, c, d, e\}$ with replacement and order is not important. Then assume each object in the set is a container, and we have 3 balls to put in containers (exactly the same as distribution energy units between Einstein solids). So the outcome aaa corresponds to putting all three balls in a, and etc. One can represent each outcome with a dot-line diagram. For instance $\bullet \; \bullet \; \bullet \mid \mid \mid$ corresponds aaa outcome. Note that we have $n-1$ lines and k balls. So total number of ways to arrange these objects is

$$\frac{(n+k-1)!}{k!(n-1)!} = \binom{n+k-1}{k}.$$

■ **Remark** Interestingly, the Einstein solid problem, and number of ways that one can choose k scoops of ice-cream in a shop with n scoops of ice-cream is the same.

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