Corrections Replies from Alexandra Emily Moylett (the author) written in red

Chapter 2

* Please discuss the approximate TSP for degree 3 planar graphs. Is such a problem NP complete? A discussion of this has been added to the start of Section 3.1. A reference has been provided showing that the TSP is NP-Hard even for degree-3 planar graphs.
* Please comment on QAOA algorithms for approximately solving NP hard problems. A new section (Section 2.3.5) has been added to discuss the use of QAOA for NP-Hard problems.

Chapter 3

* Please add a high-level explanation(s) of Xiao-Nagamochi classical algorithm. Consider adding figures explaining the key ideas. Some examples of simple optimisations utilised by these types of algorithms have been added to Section 3.2. Other examples of more technical ideas have been added to Section 3.3.1. New figures have been added providing examples of some of the more technical ideas.
* Please add a high-level explanation of the quantum algorithm used to speed up the Xiao-Nagamochi algorithm. What are parts of the algorithm that need to be implemented on a quantum computer? A clarification of this has been added to the start of Section 3.3.2. A note has also been added to Section 3.3.1 (just after Lemma 3.1) emphasising where the exponential runtime of the Xiao-Nagamochi algorithm comes from.
* Please add clarification of the statement “(quantum) failure probability can be chosen such that the algorithm is always successful”. Below heuristic h3 on page 30 This statement has been removed and further details have been added to the end of Section 3.3.2 clarifying this point. The point of this statement is that the overall algorithm succeeds if every run of the backtracking algorithm also succeeds. Choosing a suitably small probability of the backtracking algorithm failing ensures that the probability of the overall algorithm failing is bounded.
* In the section describing conclusions - please carefully discuss what speedups are obtained (in terms of n and L) for graphs of degree smaller equal 6. A discussion of this has been added to Section 3.5, as well as comparisons made in Section 3.5.1.
* In the section 3.5.2 - please correct reference to Section 16 (it does not exist) This now refers to the correct section (Section 2.2.2).

Chapter 4

* Please elaborate on the footnote on page 43. Further details have been added to the end of Section 4.1 as to why Grover search is not sufficient for a quadratic speedup in this setting, whereas quantum backtracking is. We also point the reader to Section 2.3.3 which contains a formal explanation.
* Consider adding a motivation for using the total variation distance, for which we note the relationship to hypothesis testing and data processing inequality. A connection between the total variation distance and hypothesis testing has been added to Section 4.2, as has the link between the trace distance and the data processing inequality.
* Eq. 4.4 does not express convexity of trace distance. Please clarify. Fixed (see equation 4.4 on page 46).
* Following the statement of problem 4.2, please comment on the processing time vs memory tradeoffs in classical random circuit sampling, as these are related to the Google-IBM discussion. A note has been added to Section 4.2.1 on the tradeoff between time and space for Google’s and IBM’s classical simulation ideas.
* For boson sampling problem, please clarify the significance of the applied unitary being Harr random, and the relationship to the anti-concentration condition. I am unsure what is meant by the relationship between the unitary being Haar random and its connection to the anti-concentration conjecture. A discussion of the link between the applied unitary matrix being Haar random and its significance for the Bosonic Birthday Paradox has been added to Section 4.3.4.
* Please define what is meant by a Gaussian matrix. An explanation has been added to Section 4.3.4.
* Please elaborate on the different models of photon detection in section 4.3, and their relationship to the hardness of classical simulations. Discussion on the theory of threshold detectors vs number resolving detectors has been added to Section 4.3.1. Discussion of bosonic sampling with threshold detectors is added to Section 4.3.3, noting that while there is little theory as to its complexity, for the specific problem of Boson Sampling this makes little difference due to the Bosonic Birthday Paradox. Clarification on Gaussian Boson Sampling with threshold detectors has been added to Section 4.3.6, after Problem 4.5.
* Please clarify the operation and sampling complexity of the Clifford and Clifford algorithm [we suggest to place it section 4.6.1]. Explicit runtimes for the Clifford and Clifford algorithm have been added to Section 4.6.1.

Chapter 5

* Please correct parametrization of the visibility upon discussion Hong-Ou-Mandel effect on page 58 (according to the formula, \Dalta\tau<0 gives possibly negative probabilities). The dependence of the visibility on \Delta\tau has been corrected to work for all values of \Delta\tau, including \Delta\tau<0. This change can be seen after Equation 4.51.
* Please comment on the cost and limitations of using post-selection to sample from a particular irrep [p. 84]. A comment on the cost of postselection has been provided in Section 5.4.1.
* Please comment on the similarities/differences and physical significance of the partial distinguishability models considered (i.e. those of Tichy and Remema). These two models are in fact equivalent, and were proven by Tichy. This has been clarified in Sections 4.5.1 and 5.3.
* Please add clarification of the operational or conceptual interpretation of the distinguishability parameter used. This has been clarified in Section 4.6.4 where the distinguishability parameter is originally introduced, as well as including a note that Renema et al. informally argue that their approach can also be adapted to more general models of distinguishability. A note is also added to 6.10.1 about extending the ideas of Chapter 6 to more general models of distinguishability as an open question.

Chapter 6

* Please consider providing an overall analysis of classical complexity of the presented algorithm, as a function of x, n etc, and fixed error in section 6.5. A calculation for required value of k for a constant error has now been provided in Section 6.5. Similar analysis has been added for Sections 6.6 and 6.8, as well as some correcting of the error bounds in Section 6.8 (the main conclusions of Section 6.8, that our algorithm allows classical simulation of log-depth photonic circuits under non-uniform loss, still hold).
* Please comment on the consistency of the statements “there is no polynomial time classical algorithm for computing the probability of a single outcome from n full distinguishable squeezed states” consistent with the statement “it is classically efficient to sample n fully distinguishable squeezed states…”? A comment on this has been added to Section 6.10.1, explaining that while a polynomial number of samples can give you an approximation of the probability of an outcome up to additive error, so does simply outputting that the probability is zero.

Additional corrections made by the author:

Title page:

* Updated date (March 2020 -> May 2020)
* Updated word count (now 45,000 words)

Chapters 1-6:

* Clarification of my own contributions to each publication has been made in accordance with Annex 5 of the University of Bristol Regulations and Code of Practice for Research Degree Programmes (See Section 1.3.4, and the opening paragraphs of Chapters 2-6).

Chapter 3:

* Fixed a grammatical error in Footnote 1 (“only such graphs that contain”).

Chapter 6:

* Fixed a typo in Equation 6.4 (bracket sizes were incorrect)
* Fixed a typo in Equation 6.36 (\sigma.\sigma’ has been corrected to n-\sigma.\sigma’ as x^i corresponds to \sigma and \sigma’ not matching in i places, whereas \sigma.\sigma’ denotes number of places where they do match.) This change does not affect the rest of this chapter as the \sigma.\sigma’ notation is only used in this equation and the remainder of the chapter is consistent with the idea that x^i corresponds to \sigma and \sigma’ not matching in i places.

Bibliography:

* Publication details added for Qi et al (2019) and Wu et al (2020) (previously these articles were only preprints)