Comenius University Bratislava
Faculty of Mathematics, Physics and Informatics

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Title: Labeling outcomes of quantum devices and higher-order distinguishability

Abstrakt: In this thesis, we introduce a quantum information processing task which we refer to as “quantum labeling” and identify that it as a specific instance of distinguishability tasks concerning quantum observables or positive-operator-valued measures. This specific instance arises when the ensemble we require to dis- tinguish is composed of all possible observables having identical but permuted associations of composing effects to the outcome labels. These tasks are also claimed to be of relevance when the associations between effects and outcome labels of a quantum measurement device is lost somehow, rendering it “unlabeled”. We investigate this task using higher-order quantum theoretic notions so as to consider the full extend of possibilities. Subsequently, we study the task within the single and multiple-shot regimes and for different possible schemes including perfect, imperfect unambiguous and minimum-error. The statistical notion of quantum incompatibility and its role as a resource in various quantum information processing tasks have been studied in the recent years. This notion related to joint measureability or implementability of quantum devices has been extended to higher-order quantum theoretic measurements, referred to as quantum testers. In this thesis, as a second avenue other than that on labeling tasks, we explore the resourcefulness of incompatibility of higher-order quantum theoretic measurements in distinguishability tasks.

V tejto práci definujeme úlohu spracovania kvantovej informácie, ktorú označujeme ako ”kvantové označovanie”, a identifikujeme ju ako špecifický prípad úloh rozlišovania týkajúcich sa kvantových pozorovateľných veličín alebo kladne-semidefinitných operátorových mier. Tento špecifický prípad vzniká vtedy, keď súbor, ktorý požadujeme rozlíšiť, pozostáva zo všetkých možných pozorovateľných veličín, ktoré majú identické, ale permutované efekty k výsledkom. Tvrdí sa, že tieto úlohy majú význam aj vtedy, keď sa asociácie medzi efektmi a výsledkami kvantového meracieho zariadenia nejakým spôsobom stratia, čím sa stane „neoznačeným“. Túto úlohu skúmame v rámci matematických štruktúr vyššieho rádu, ktorá zahŕňa najvšeobecnejšie možné scenáre. Následne skúmame úlohu v rámci režimu jedného a viacerých použití a pre rôzne možné schémy vrátane perfektnej, jednoznačnej a minimálnej chyby. Štatistický pojem kvantovej nekompatibility a jej ”zdrojová” úloha pri kvantovom spracovaní informácie boli predmetom intenzívneho štúdia v posledných rokoch. Tento pojem súvisiaci s pojmom spoločnej merateľnosti, resp. realizovateľnosti kvantových zariadení, bol rozšírený na kvantovo-teoretické merania vyšších rádov, označované ako kvantové testery. Ako druhú tému v tejto práci skúmame nekompatibilitu kvantovo-teoretických meraní vyššieho rádu v úlohách rozlišovania.

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