

Indirect Measurement

The concept of indirect measurement is to couple a probe to a system via a unitary interaction and then perform a measurement on the probe. In this manner, one can learn information regarding the system, yet the information is learned indirectly by measuring only the probe. This is similar to the measurement procedure of von Neumann described in [13, pp. 441-445]. Ozawa showed that even though the indirect measurement models are only a subclass of all the possible quantum measurements, every measurement is statistically equivalent to an indirect measurement model [669].

Additionally, one can generalize this scheme to more than one probe, particularly when more than a single quantity is desired to be known regarding the system. For example, one might consider the measurement of non-commuting observables by coupling two probes to the system, one probe designed to extract information regarding the position of the system and the other probe designed to extract information regarding momentum. The use of two probe “meters” to extract both position and momentum information was proposed by Arthurs and Kelly [670]. An additional characteristic of this scheme is that the positions of the two probe meters commute in [670], hence ideal simultaneous measurements can be made of the positions of the two meters.

It was found in [671] that the use of correlated probes can provide more precise joint measurement outcomes than if the same probes were individually applied. However, Heisenberg’s uncertainty relationship was found not to be violated.