Indirect measurement of a thermodynamic system

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In tasks of quantum thermodynamics and many body physics, one often needs to extract information about the system by making some types of measurements. Typically, these are energy measurements, particle number measurements, or work measurements. However, in certain cases these types of measurements are not directly accessible. For example, performing an energy measurement on a many-body system is experimentally unfeasible. In such cases it might be still possible to use a proxy - an auxilliary system, which we call a probe. This probe interacts with the system and some information is transferred to it. I will show that one can define a measure that shows how much information has been transferred and therefore can extracted, by measuring this probe. This measure is known as observational entropy (also known as coarse-grained entropy), now generalized to include arbitrary generalized measurements. We will demonstrate the general theory on the example of the well-known and experimentally realizable von Neumann measurement scheme, which translates measurement of any quantum observable on the system to a position measurement of a classical particle. This theory creates a conceptual framework of treating general information extraction from a quantum system, by any (most general) means necessary. While it has already found applications specifically in defining non-equilibrium thermodynamic entropy that characterizes evolution of quantum many-body systems, this generalized definitions could find applications in open systems, especially in entropic considerations for example in driven systems, in quantum and information engines, and generally in nanoscale thermodynamics, which are of growing both theoretic and experimental interest.