

## 23.4: Postulate 4- Expectation Values and Collapse of the Wavefunction

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If a system is in a state described by a normalized wave function  $\Psi$ , then the average value of the observable corresponding to  $\hat{A}$  is given by:

$$\langle A \rangle = \int_{-\infty}^{\infty} \Psi^* \hat{A} \Psi d\tau. \quad (23.4.1)$$

An important consequence of the fourth postulate is that, after measurement of  $\Psi$  yields some eigenvalue  $a_i$ , the wave function immediately “collapses” into the corresponding eigenstate  $\Psi_i$ . In other words, measurement affects the state of the system. This fact is used in many experimental tests of quantum mechanics, such as the Stern-Gerlach experiment. Think again at the sequential experiment that we discussed in [chapter 23](#). The act of measuring the spin along one coordinate is not simply a “filtration” of some pre-existing feature of the wave function, but rather an act that changes the nature of the wave function itself, affecting the outcome of future experiments. To this act corresponds the collapse of the wave function, a process that remains unexplained to date. Notice how the controversy is not in the mathematics of the experiment, which we already discussed in the previous chapter without issues. The issues rather arise because we don’t know how to define the measurement act in itself (other than the fact that it is some form of quantum mechanical procedure with clear and well-defined macroscopic outcomes). This is the reason why the collapse of the wave function is also sometimes called the *measurement problem* of quantum mechanics, and it is still a source of research and debate among modern scientists.

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