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Coherent Control of the Photo-isomerization of Retinal in Bacteriorhodopsin

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Proteins are highly evolved structures in which their central role is to direct chemical or solar energy into functions. A central tenet in biology is that proteins have evolved to stabilize the transition states processes directing energy transduction into functions. In the transition state region, the motions are fairly localized such the wave properties of matter can lead to destructive and constructive interferences that have a pronounced effect on transmission probabilities along reaction coordinates. Further, the time scale for motion through a transition state, often involving a conical intersection, is comparable to the currently believed decoherence times for electronic and vibrational degrees of freedom governing this motion. The question arises whether the phases of the underlying matter waves could play a role in directing biological processes. In order to address this question, we exploited coherent control protocols using shaped laser fields to determine whether or not the absolute quantum yield of the photo-isomerization of retinal in bacteriorhodopsin (bR) could be achieved using weak field conditions to probe the natural function. Through feedback-controlled amplitude and phase variation of the spectral components comprising the excitation pulse, we could selectively enhance or suppress the isomerization quantum yield by 20% in either direction. Our experimental observation illustrates that the wave properties of matter, as manifest on vibrational quantum coherences, can play a role in biological processes to the point that they can even be manipulated.

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