Stark effect and generalized Bloch-Siegert shift in a strongly driven two-level system

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The characteristics of matter and light become intertwined upon interaction. Natural or artificial atoms can be coupled to the zero-point vibrations in a cavity, or, to a driven laser field. One of the effects of the field is the dynamic (ac) Stark shift of the energy levels. An additional correction, the Bloch-Siegert shift, appears for an oscillating, rather than circularly polarized field. Our two-level system was realized as a superconducting qubit driven in an ultrastrong fashion by via the nonlinear Josephson energy. We measured large Stark shifts of the qubit level spacing unseen in atomic systems. The shifts are found to exhibit unconventional and to some extent nonmonotonic dependence on the field amplitude. We extract a contribution due to the Bloch-Siegert shift. This work is the first observation of Bloch-Siegert type of correction in driven systems other than atomic systems or magnetic resonance. Unlike all but few previous experiments, we have to go beyond the usual lowest-order such correction in order to account for the data. We refer to these additional changes in the qubit level splitting as the generalized Bloch-Siegert shift. The quasienergies of the dressed two-level system were probed by resonant absorption via a cavity, and the results are in agreement with a calculation based on the Floquet approach.