Muller and Noordam Reply: In our paper [1] we showed how off-resonant levels in a quantum system can conspire to counteract effects due to large coupling between degenerate levels. Corless and Stroud [2] claim several spectacular effects to happen due to such couplings in a real Rydberg atom, based on a treatment that considered only a single Rydberg manifold. Our paper [1] presented a quantum system that fails to display any such effects in a full treatment, but reduces to the Corless-Stroud model under the single-manifold approximation (and thus reproduces the results of Ref. [2] as an artifact).

To serve the counterexample purpose, it is immaterial if our model is an exact representation of a Rydberg atom, and indeed we never claimed it was. Crucial, however, was that our model should be amenable to exact analytic solution, to provide unassailable proof that the results predicted from it with the aid of the single-manifold approximation of Ref. [2] are in error. To achieve this, we had to construct the model violating some of the well-known properties of true atoms: we allow negative principal quantum numbers n, equip each n with an equal number of l sublevels (which again results in the n independence of the coefficients S_{kl} signaled by Madsen [3]), give them a constant energy spacing, ignore all other n dependence of matrix elements, and neglect the presence of continuous spectra. Yet all these shortcomings are mere trifles compared to the assumption made in Ref. [2] that these levels do not exist at all.

In fact, none of the approximations of our model are really bad. The model does not identify $|n = 1, l = 0\rangle$ with the ground state as suggested by Madsen [3], but uses a separate state $|g\rangle$ with the correct properties. This does not make the model inconsistent, just different from reality. This difference is entirely without consequences: only a limited number of levels below the resonant one will get populated in our model, and states with negative n (or $n = 1$) are not among those. That states far outside the populated energy band (such as the unphysical duplicate of the ground state) have in reality properties that are very different from what our model assumes, does not result in any observable effect, as long as these properties do not change the fact that these states are not populated.

The important result of our paper is that we show that the arguments brought forward in [2] are not sufficient justification for the application of the single-manifold approximation, so that the rather counterintuitive results of Ref. [2] are shown to be basically unfounded. In addition, our method for solving the model shows the way to find suppression of the mixing effects predicted by Ref. [2] in general: Every model will have a basis χ_i that diagonalizes the laser interaction (a representation of $\mathbf{E} \cdot \mathbf{r}$). In this basis the atomic Hamiltonian, also being a local operator, can only couple near neighbors (i.e., states with nearly the same laser potential), organizing the basis states into chains. The atomic evolution will necessarily have to propagate the wave function along these chains (the "orbits"), the packet thus experiencing only a slow variation of the amplitude of the laser potential in the course of their orbit.

In any such model, suppression of the mixing will occur if the initial state couples only to those basis functions for which this diagonal element $\langle\chi_i|r|\chi_i\rangle$ vanishes, or at least is small and n-independent. Improved models, as yet not amenable to analytic solution, will have to share this property with our model, since the real atom has it: the laser interaction is diagonal in a position basis, zero or small near the origin, and the ground state from which these regions are populated is confined near the origin too. The points brought forward in the Comment by Madsen [3] do not destroy any of these properties, they just modify the details of the propagation along the orbits. For instance, dropping the dipole approximation would allow not only the amplitude, but also the phase of the laser interaction to change (smoothly) along the orbit. This does not affect the adiabaticity of the laser potential felt by the electron, and thus the suppression of the n^2-divergent mixing as reported by Ref. [2]. We could have included nondipole effects easily, but we refrained from doing so to stay on par with the treatment of Ref. [2]. Our model should be considered as the minimal one that incorporates all ingredients required for exhibiting suppression.

In conclusion, we constructively showed the approximations used in Ref. [2] to be inadequate, and the predictions from it to reverse in our extended model (which we consider to capture all the essentials of the problem under study). Although we fully agree with Madsen that essential-state models are tricky, that their use should be discouraged and their conclusions eyed with suspicion, we want to point out that Madsen offers no direct proof or even an indication that any of the modifications needed to erase the remaining differences between our model and a true atom would cause a significant change in the predicted results. We believe they will not.

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