“Breakups are Complicated: An Efficient Representation of Collisional Breakup in the Superdroplet Method” by Emily De Jong et al.

The article discusses the conceptual picture of collisional breakup and an algorithm for its representation in the Lagrangian particle-based schemes (“superdroplet method”). The proposed numerical implementation of the collisional breakup follows the original algorithm for the collision-coalescence process in the superdroplet method, conserving the number of superdroplets after each event. The fragment sizes are sampled stochastically from idealized/empirical fragment size distributions. The authors also performed idealized box and one-dimensional simulations to understand its performance with artificial size-independent and empirical size-dependent fragment size distributions. After the initial transient phase, approximately steady-state droplet size distributions are achieved due to the balance between coalescence and breakup. Moreover, the one-dimensional simulations show a minor difference with and without collisional breakup, likely due to shallower clouds.

The numerical implementation of the collisional breakup is a critical step for further developing particle-based microphysics schemes. Overall, the topic is well presented, and the manuscript is clearly written. However, as Axel Seifert pointed out in his comments, there is a need to clearly separate the steps between the reference approach closer to physics and its numerical simplifications for practical applicability in realistic cloud conditions. It also requires justification of the simplification through the comparison with reference simulations. I think that’s the way model development should proceed in general.

The manuscript is well-suited for Geoscientific Model Development. However, it requires addressing the following specific comments:

- Treating the outcome of a filament breakup event through only two size categories for a colliding superdroplet pair (without introducing a new superdroplet) is a significant simplification and physically inconsistent (at least locally). I think Axel Seifert also made a similar comment. Clearly, there is a need to compare the proposed simplification with a reference run without that simplification. Do we get similar results and similar convergence properties for both approaches? Since the paper's primary focus is to introduce a new breakup algorithm, such a comparison is required. It would be difficult to convince readers of the applicability of the proposed algorithm in more realistic cloud simulations without justifying this simplification in a simpler setup like the current one. Implementing an approach where a new superdroplet is created during breakups would be straightforward in the present box or one-dimensional configuration.

- The collisional breakup introduces an additional element of stochasticity through random sampling of a fragment size distribution. Hence, it’s essential to know the convergence properties (with the number of superdroplets) of the mean and variance of drop statistics. No such test is presented in the paper.

- The collisional breakup has almost negligible influences on cloud/rain properties in the one-dimensional test presented here due to a shallow cloud condition. The authors could also test the scheme in an idealized two-dimension deep convection with only warm phase physics. It would help understand the performance of the scheme in more realistic dynamics and the influence of associated feedback.

Minor comments:

- Line 159: "…stochastic stochastic sampling…"
- Figure 4b: Why is a higher Ec value (0.99 vs. 0.95) used here than the deterministic fragmentation function case?
- L287: "The property-independent …" Do you mean a "property-dependent" case here?
- L294: Do you mean a "property-independent" case here?