## 4. Conclusion

The alternating scheme, structured as  $V^n \to V^{n+\frac{1}{2}} \to z^{n+1} \to V^{n+1}$ , cancels the dominant  $\Delta t^2$  commutator error. The resulting truncation error begins at  $\Delta t^3$ , and the global integration error scales as  $\mathcal{O}(\Delta t^2)$ . This establishes second-order accuracy over the first-order Lie method.

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