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Manipulating Flames with AC Electric Fields

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Time-oscillating electric fields applied to plasmas present in flames create steady flows of gas capable of shaping, directing, enhancing, or even extinguishing flames. Interestingly, electric winds induced by AC electric fields can be stronger that those due to static fields of comparable magnitude. Furthermore, unlike static fields, the electric force due to AC fields is localized near the surface of the flame. Consequently, the AC response depends only on the local field at the surface of the flame - not on the position of the electrodes used to generate the field. These results suggest that oscillating electric fields can be used to manipulate and control combustion processes at a distance. To characterize and explain these effects, we investigate a simple experimental system comprising a laminar methane-air flame positioned between two parallel-plate electrodes. We quantify both the electric and hydrodynamic response of the flame as a function of frequency and magnitude of the applied field. A theoretical model shows how steady gas flows emerge from the time-averaged electrical force due to the field-induced motion of ions generated within the flame and by their disappearance by recombination. These results provide useful insights into the application of AC fields to direct combustion processes.