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Theoretical explanation for the formation of zebra stripes in the inner radiation belts despite the absence of electric or magnetic field fluctuations.

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Zebra stripes are structured peaks and valleys observed on spectrograms of protons and energetic electrons trapped in the inner radiation belts. They have been observed since the 1960s and even though they are transient structures, statistical studies have shown that they are commonly observed and correlated with geomagnetic Kp and Dst indices. Since their discovery, various mechanisms relying on wave-particle interactions have been suggested to explain the formation of zebra stripes. More recently, Lejosne and Roederer (JGR, 121, 2016) have presented a kinematic argument (supported with numerical results) with less constraints than models relying on drift-orbit mechanisms. In this communication, we present a theoretical derivation of zebra stripes from first principles and demonstrate that 1) their formation has a kinematic origin, and 2) that it does not require the presence of electric or magnetic field fluctuations. However, we show that the inclusion of electric or magnetic field fluctuations does not prevent the formation of zebra stripes, and our analysis therefore provides an explanation as to why simulations of drift orbit processes have been able to reproduce zebra stripes patterns.