Observation and Theory of a Substorm Event Observed on December 21, 2006

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We present observation and theory of an auroral substorm event observed on December 21, 2006. The substorm auroral arc was observed by deploying the Imager of Sprites and Upper Atmospheric Lightnings (ISUAL) aboard the FORMOSAT-2 satellite as well as the THEMIS ground-based All Sky Imagers. The ISUAL provides optical observation of vertical structure of substorm auroral arcs from the sideway with a high cadence of 1.4 sec with 1 sec exposure. The THEMIS ASIs provide vertical upward view of auroras with a cadence of 3 sec. By combining the ISUAL observations with the THEMIS ASI observations and ground-based magnetometer data we were able to obtain the dynamical process and structures of the auroral substorm event from the arc appearance to arc intensification to arc breakup. In particular, prior to substorm onset we obtained the fine azimuthal structure with azimuthal mode number of ~200 of the onset arc and the exponential growth of the arc luminosity with growth rate of ~5.3 χ 10^{-3} s^{-1}. The observations suggest that an instability with azimuthal mode number of ~200 responsible for producing the discrete substorm onset arc is excited about 1 minute before the onset of substorm expansion and its amplitude grows exponentially until nonlinear effects set in to break up the arc.