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A Microscopic Particle Image Velocimetry Study of the Structure of Transitional Capillary Flow V.K. NATRAJAN, K.T. CHRISTENSEN, Mech. Science and Engineering Dept., Univ. of Illinois — Instantaneous velocity realizations in the streamwise–wall-normal plane of a 536-micron glass capillary are acquired by micro-PIV for Reynolds numbers in the transitional and fully-turbulent regime (Re=2300, 2700, 3100 and 4500, respectively). Examination of the ensembles at the transitional Re reveals that they are composed of a subset of velocity fields illustrating laminar behavior and a subset that capture significant departure from laminar behavior. The instantaneous non-laminar velocity fields at the transitional Re contain multiple spanwise vortices that appear to streamwise-align to form larger-scale interfaces inclined slightly away from the wall. These characteristics are consistent with hairpin vortex packets that are often observed in transitional and fully-turbulent wall-bounded flow at the macroscale. Similar spatial signatures are also noted in various estimates of conditionally-averaged velocity fields. Finally, eigenvalue spectra are computed via proper orthogonal decomposition (POD) for the non-laminar subsets at the transitional Re and reveal increasing energy content within the higher-order modes as the flow matures to a fully-turbulent state. Such behavior indicates that this maturation process is accompanied by a gradual evolution of smaller wall-normal length scales that become more energetic with increasing Re.

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