

MAR08-2007-020247

Abstract for an Invited Paper
for the MAR08 Meeting of
the American Physical Society

Zero CTE Glass in the Hubble Space Telescope

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Orbiting high above the turbulence of the earth's atmosphere, the Hubble Space Telescope (HST) has provided breathtaking views of astronomical objects never before seen in such detail. The steady diffraction-limited images allow this medium-size telescope to reach faint galaxies fainter than 30th stellar magnitude. Some of these galaxies are seen as early as 2 billion years after the Big Bang in a 13.7 billion year old universe. Up until recently, astronomers assumed that all of the laws of physics and astronomy applied back then as they do today. Now, using the discovery that certain supernovae are "standard candles," astronomers have found that the universe is expanding faster today than it was back then: the universe is accelerating in its expansion. The Hubble Space Telescope is a two-mirror Ritchey-Chrétien telescope of 2.4m aperture in low earth orbit. The mirrors are made of Ultra Low Expansion (ULE) glass by Corning Glass Works. This material allows rapid figuring and outstanding performance in space astronomy applications. The paper describes how the primary mirror was mis-figured in manufacturing and later corrected in orbit. Outstanding astronomical images taken over the last 17 years show how the application of this new technology has advanced our knowledge of the universe. Not only has the acceleration of the expansion been discovered, the excellent imaging capability of HST has allowed gravitational lensing to become a tool to study the distribution of dark matter and dark energy in distant clusters of galaxies. The HST has touched practically every field of astronomy enabling astronomers to solve many long-standing puzzles. It will be a long time until the end of the universe when the density is near zero and all of the stars have long since evaporated. It is remarkable that humankind has found the technology and developed the ability to interpret the measurements in order to understand this dramatic age we live in.