Pathfinder Technologies in the Post-HST Era
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Abstract

Novel optical designs as well as innovative detectors enable long-duration balloon (LDB) missions to achieve spatial resolutions comparable to HST over large fields. Advances in UV-visible wavelengths. Improvements in balloon technology make significantly larger missions to be flown at higher altitudes than were possible just a decade ago. During the 1993-94 mission, the end of HST operations and future large UV-visible missions, a 2+ meter telescope will provide 2-3 weeks of dark-time observations per year for the current astronomical community. The LDB-mission can serve as a platform to fly new instrument concepts. For example, a 2+ meter telescope equipped with a Fabry-Perot instrument is ideal for producing 2-D velocity maps at an efficiency of 10 times that of HST. Such a mission could study kinematically the assembly of galaxies from $z \approx 1.5$ to the present, measuring empirically the dark and luminous matter as a function of galaxy radii for different epochs. Perhaps, it could also be used as a pathfinder to TPC-C. A proposed conventional balloon mission, called KITE, seeks to demonstrate the feasibility of the novel optical design plus new detector technologies, as well as verify that all pointing and thermal issues that have plagued previous missions have been mitigated. The telescope design and two example missions are discussed.

Novel Telescope Design is shared by both balloon missions

**Excellent Performance**

**Novel Telescope Design**

Layered, Redundant Attitude Control System (ACS) makes use of photon-counting detector

- Pendulum swing, which has an amplitude of ~10° and a period of 10 sec, is removed by our ACS
- The technique of using address offsets in the detector memory to compensate for minor pointing errors was pioneered by Ed Jenkins at Princeton in the 1980s for the Interstellar Medium Absorption Profilometry Survey (IMAPS) Mission.

**Wide-field Kinematics**

- EBCOD Detector 2% of Solar Blind (40% portion) of WFCPC science efficiency, 80% more than GALEX with 85% in
- Balloon-borne 0.75 m Telescope Near-UV (200 nm < $\lambda$ < 400 nm) Fabry-Perot + Long-slit spectrograph

**KITE – Mass Outflows from AGN Studies**

The Fabry-Perot will produce velocity maps of the NLR around nearby Seyferts for several species with different ionization potentials, providing important information on the physics of mass outflows such as for AGNs affecting the large-scale structure in the early universe.

- a) [O III] image of the NLR of NGC415.
- b) Model representing the geometry and velocity field.
- c) Extracted velocities (gray) compared to observed radial velocities of bright-emission components.
- d) The NLR and host-galaxy geometries as seen from our line of sight.

**KITE – Stellar Evolution via Binary Studies**

The need for fundamental data for evolved supergiants is underscored by the long-standing discrepancy between the pulsational and evolutionary masses of Cepheids.Stars in the upper right of HR diagram can have different masses, but same L & T.

**HAWK**

Hierarchical Assembly through Wide-field Kinematics

- 2 m telescope on long-duration balloon (LDB)
- Nearly diffraction limited 2-D velocity maps, DM and luminous mass content as a function of radius
- Empirically measure how galaxies evolve from $z \approx 1.4 - 1.5$
- Measure the Tully-Fisher Relation (TRF) for spiral galaxies

**HAWK – Measure velocities for a flux-limited sample of gas emission in 10 Mpc³ volume**

- HDF
- HIF Redshift Catalog

**Galaxies Not Well Organized**

To Be Explored by JWST

- First Star Formation
- Earliest Galaxy Structures
- To Well-Organized Galaxies

**To Be Explored by HAWK**

- Galaxy Evolution 2D & Visible Mass
- To be observed by HAWK

**Most Distant Galaxies should have dwarf satellites**

**A Versatile Instrument for Other Studies**

- • Star Formation Rates in XUV galaxies
- • Post-AGB and post-early-AGB
- • New classes of objects discovered by Gaia
- • Jets and circumstellar shells.

**Why Ground-based Telescopes with Adaptive Optics can’t do it!**

**IR Ground-based Telescopes**

- Have large Thermal Backgrounds!
- PSF of 10 m with AO only becomes comparable at IR wavelengths

**Image Quality Comparison**

- PSF compared for 10 m (HAWK)
- PSF compared for 10 m (HAWK)

**Aperture, Parallax Comparison**

- 4m, 8m, 20m, 100m
- 4m, 8m, 20m, 100m

**Modeling Galaxies as a Function of Z**

- $z=0.58$
- $z=1.36$

**Rotation Curve**

- $V = 120 km/s$
- $V = 120 km/s$

**Data collection**

- GALEX: UV and NIR
- HST: UV and NIR

**Galaxies with Various Morphologies**

- S0, Sa, Sb, Sc
- S0, Sa, Sb, Sc

**Data from Ford et al. 2002**