The Great Andromeda Galaxy

Introduction

- Martin Schwarzschild
- Scientific career
  - Stellar structure and evolution
  - Dynamics of stellar systems
  - Numerical methods
  - Innovative observations
- Centenary conference

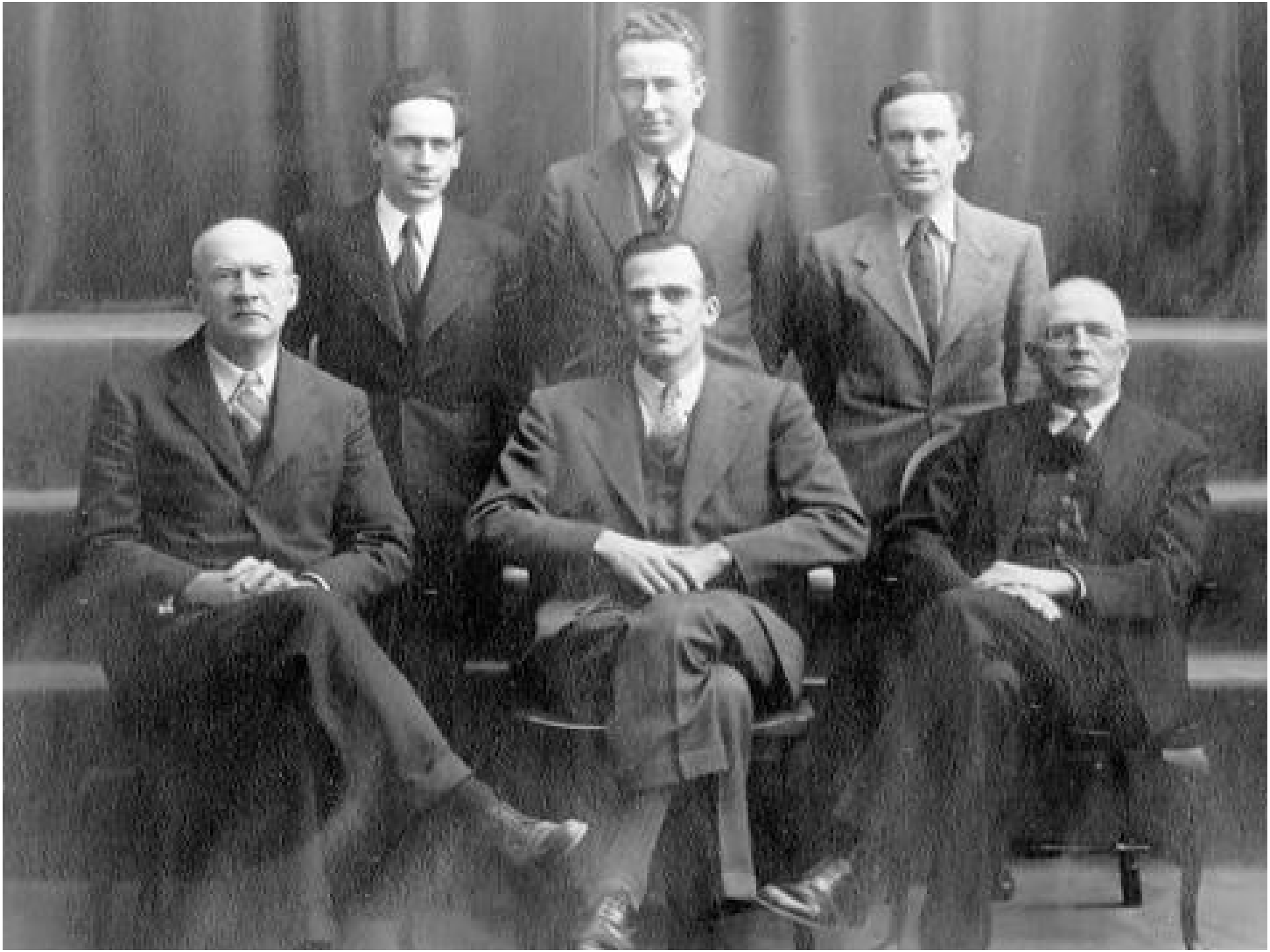
Synopsis (1)

- Born 31 May 1912, in Potsdam
  - Second of three children
- Father Karl volunteered for German Army in WWI and contracted incurable disease, died 1916
  - Family then moved back to Göttingen
- PhD in 1935 on the Pulsation Theory of δ Cep Stars
- Postdoctoral positions
  - 1936-1937: Oslo (via Leiden to visit Hertzsprung/Oort)
  - 1938-1940: Harvard (turning down offer from Eddington)
    - Here he met Barbara Cherry; they married in 1945
- Columbia 1940-1947, interrupted by WWII

1939

Synopsis (2)

- Volunteered for US Army Dec 1941
  - Army Intelligence, including duty in Italy
  - Declined working on Manhattan project
- 1947 to Princeton
  - Together with Lyman Spitzer
  - Simple house on 12 Ober Road
  - Higgins Professor 1951
- Retirement 1979
  - Moved to Pennswood in early nineties
- Passed away 10 April 1997
  - Ten days after Lyman
  - Barbara lived in Pennswood until 2007



Stellar Structure and Evolution

- Stellar structure and evolution
  - Pulsating stars
  - Granulation of the Sun and theory of convection
  - Ages of globular clusters
  - Red giants (with Fred Hoyle)
  - Helium flash and thermal pulses (with Richard Härm)
- Pioneering use of numerical methods
  - And full understanding of the relevant physics
  - Very fruitful partnership with Richard Härm
- Textbook *Structure and Evolution of the Stars*
  - Written in Paris in six months (dictated) in 1957
  - Brilliant summary of physics of stellar interior

With Richard Härm

Balzan Prize 1994

- Awarded to Martin and Fred Hoyle for their joint work on red giants
- Martin's comment on hearing the news:
  - They have given me a prize for something I did 40 years ago: ridiculous!

Structure and Evolution of the Stars

If simple perfect laws uniquely rule the Universe, should not pure thought be capable of uncovering this perfect set of laws without having to lean on the crutches of tediously assembled observations? True, the laws to be discovered may be perfect, but the human brain is not. Left on its own, it is prone to stray, as many past examples sadly prove. In fact, we have missed few chances to err until new data freshly gleaned from nature set us right again for the next steps. Thus pillars rather than crutches are the observations on which we base our theories; and for the theory of stellar evolution these pillars must be there before we can get far on the right track.

Martin Schwarzschild (1958)

Observational Activities

- Granulation of the Sun
- Chemical composition of high and low-velocity stars
- Stellar populations in M31 and NGC 205
- PI of Stratoscope 1 and 2
  - Included high angular resolution observations of M31's asymmetric nucleus
- Isophote shapes of elliptical galaxies
  - With special camera

Dynamics (1)

- This topic was a ‘hobby’ for much of Martin’s career
  - And a field into which ‘he could quietly retire at age 67’
- Early work (1950-1954) included
  - Spitzer-Schwarzschild mechanism
  - Orbital properties of MW halo stars
  - Dark matter content of galaxies and clusters (1954)
    - Including analysis of kinematics of M31, M33 and N3115, and Coma cluster
    - Estimate dark matter assuming asymmetry of M31 caused by M32
    - High M/L’s noted, as well as possible role of white dwarfs
    - Implication that dark matter fraction might be a function of scale
    - Paper prompted a reaction from Jan Oort

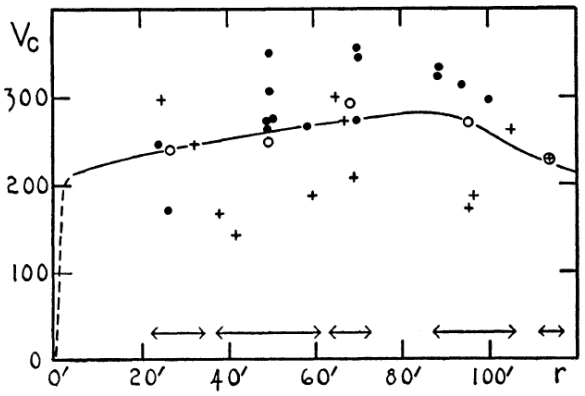


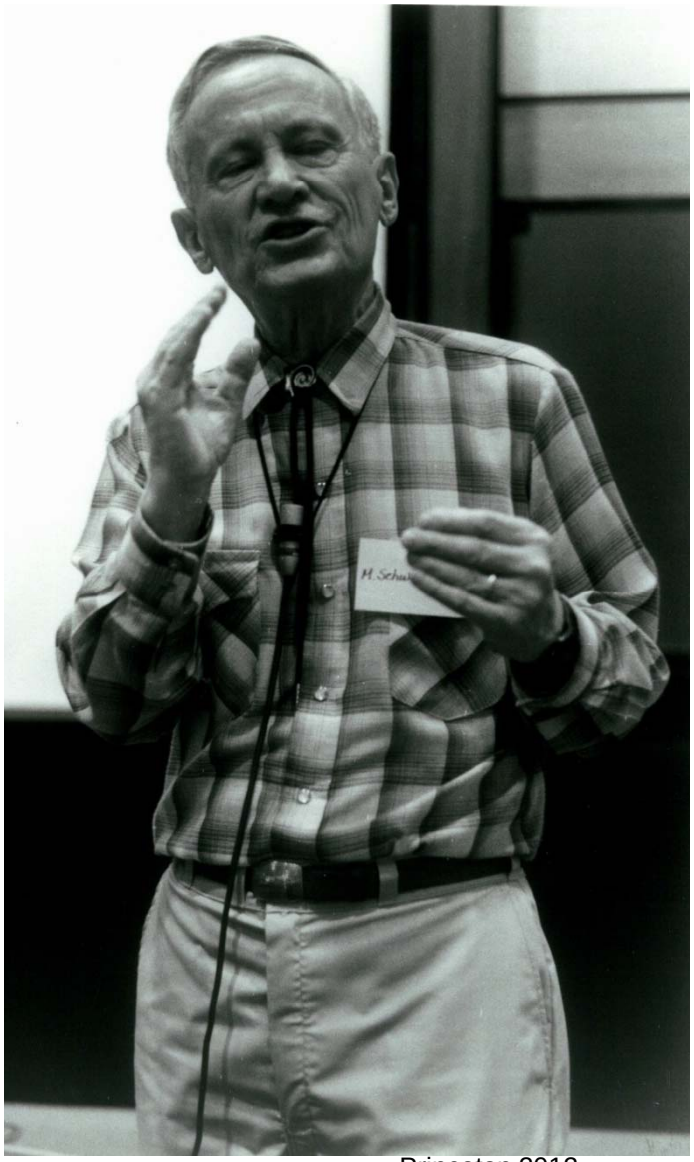
Figure 1. Circular velocity in the Andromeda Nebula in km/sec. Dots: observations on north following side. Crosses: observations on south preceding side. Circles: normal points. Curve: computed under assumption of identical mass and light distributions.

Dynamics (2)

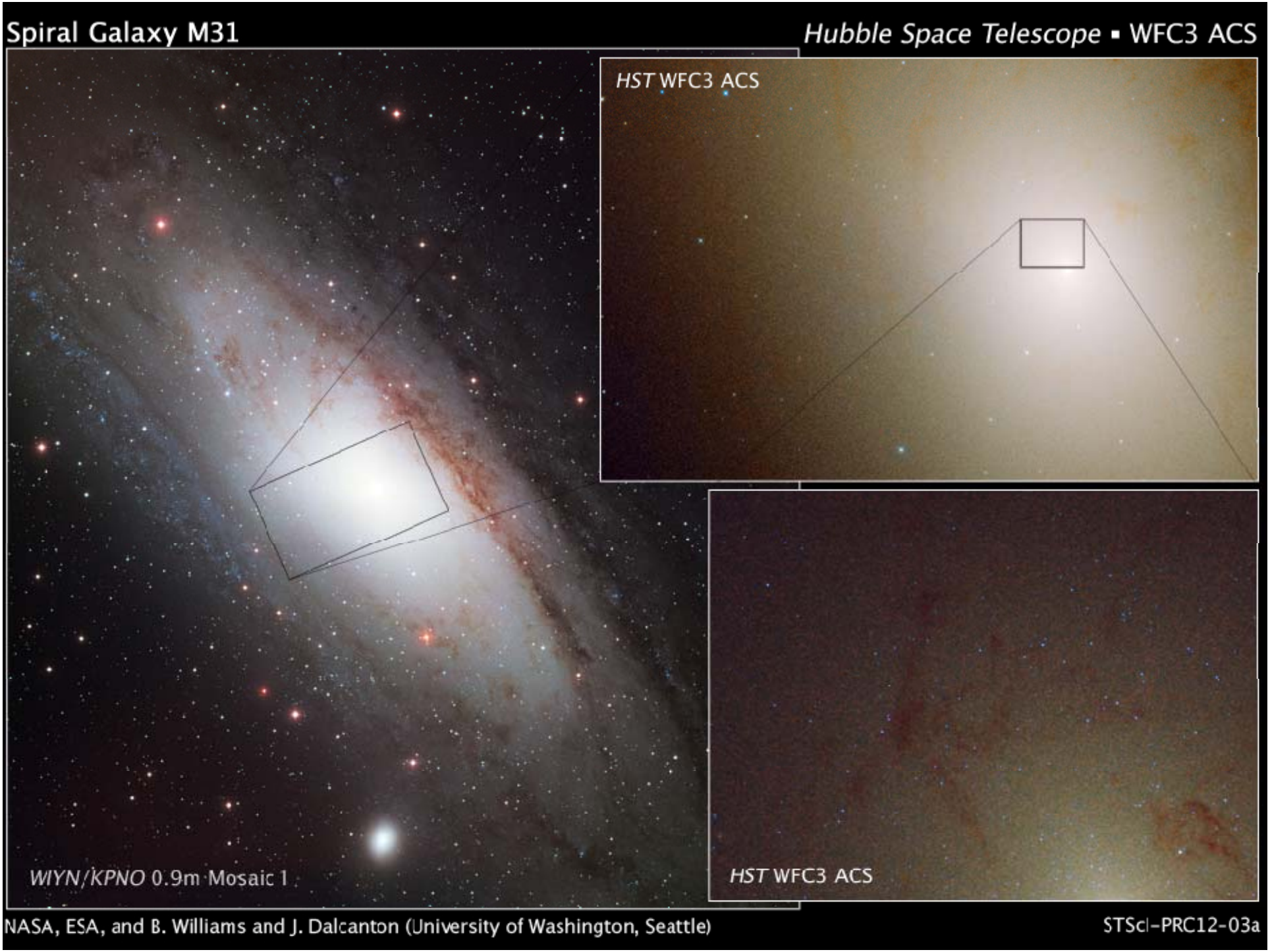
- Martin returned to the field in the mid-seventies
  - Following the Stratoscope II observations of M31 (1974)
  - Dynamical models for M31 (with Maria Teresa Ruiz, 1976)
- Main Focus
  - Numerical construction of dynamical models for triaxial elliptical galaxies (1977 onwards)

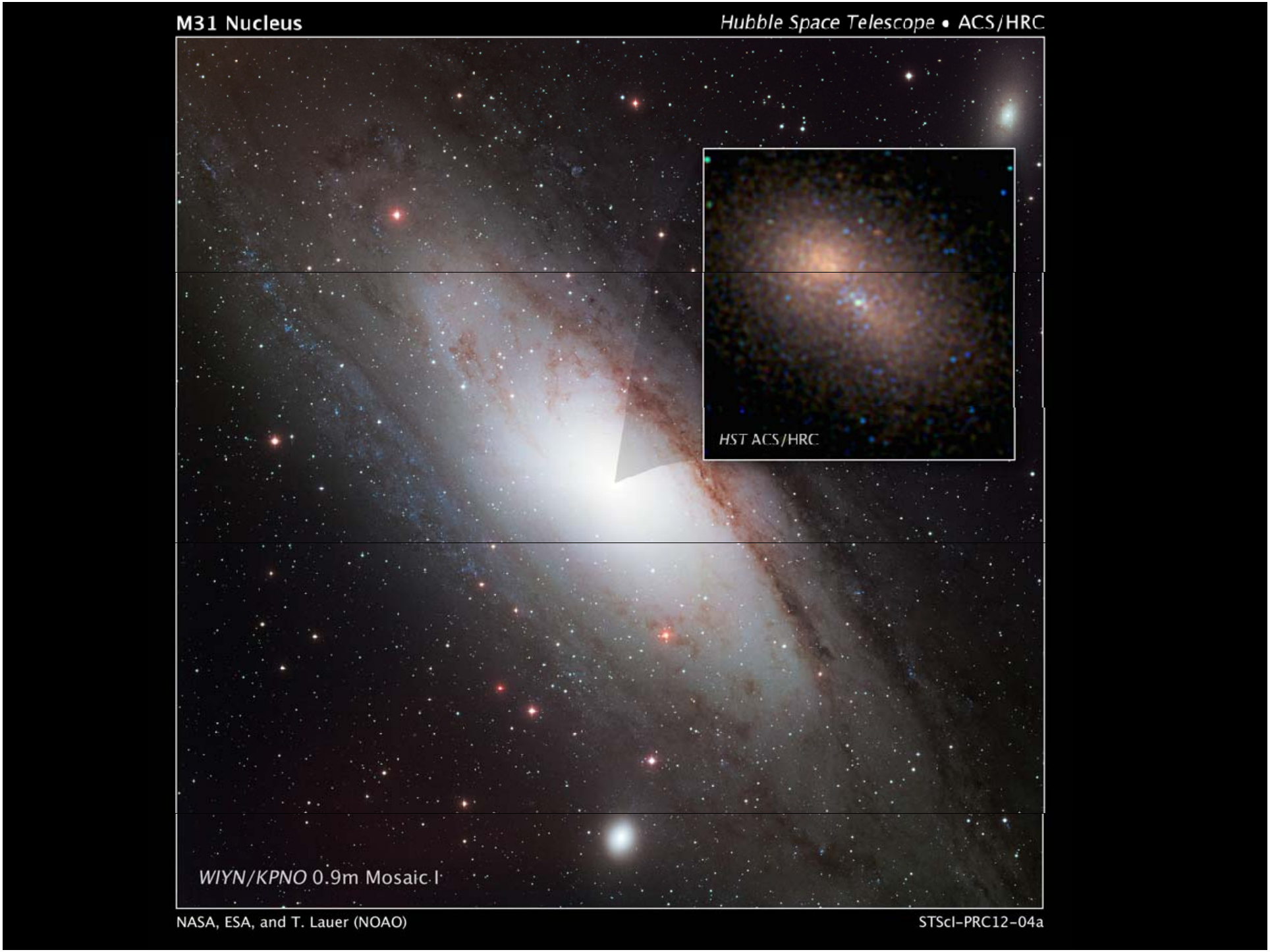
Martin as a person

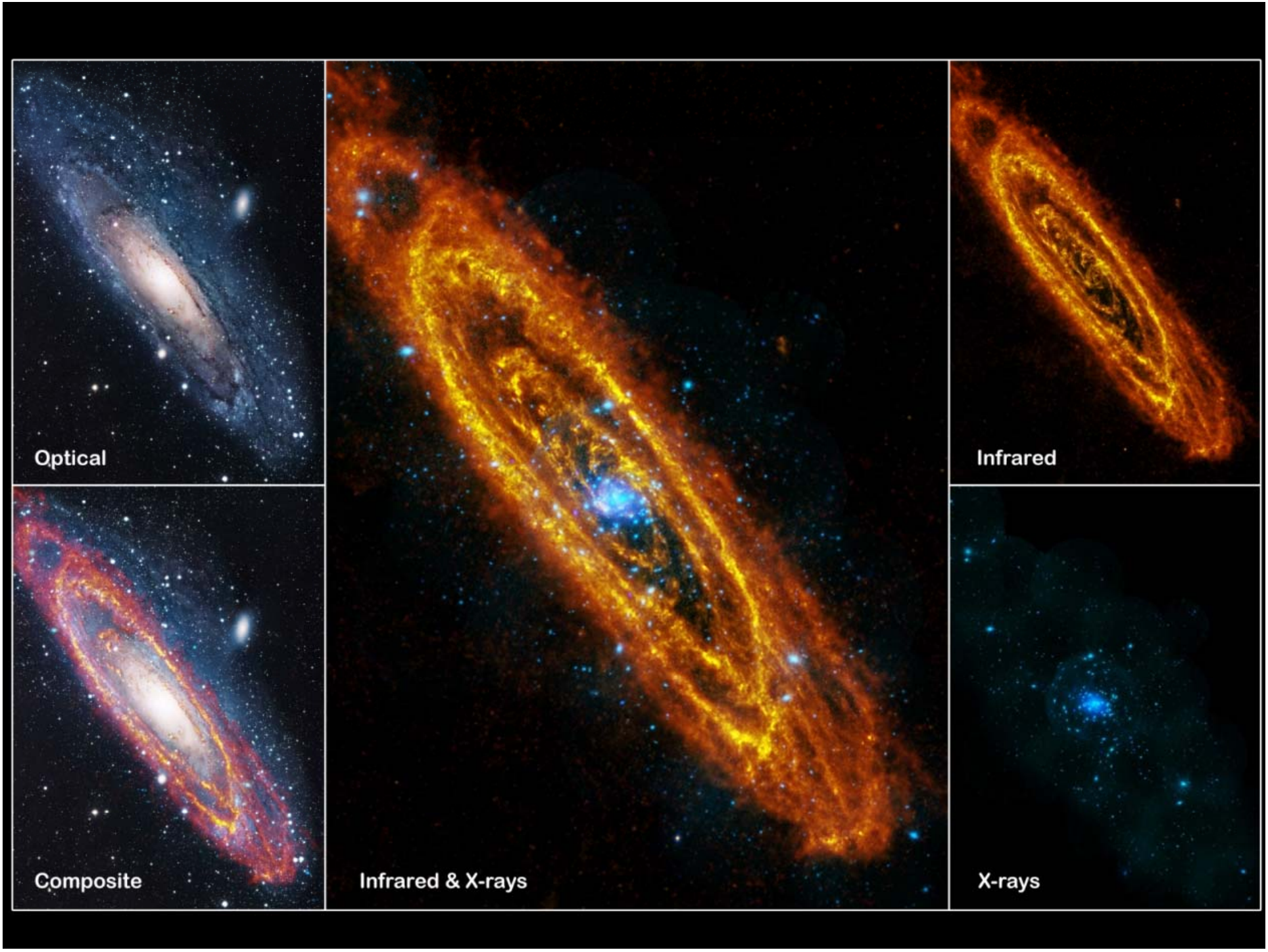
- Transparent personal integrity and ability to motivate
- Tremendous understanding and clarity of thought
  - ‘Benedictions’ at Tuesday Lunch
  - Summaries at, e.g., AAS meetings
  - Introductions at conferences
- Legendary diplomatic skills
- Exemplary modesty about his own achievements



Princeton 2012

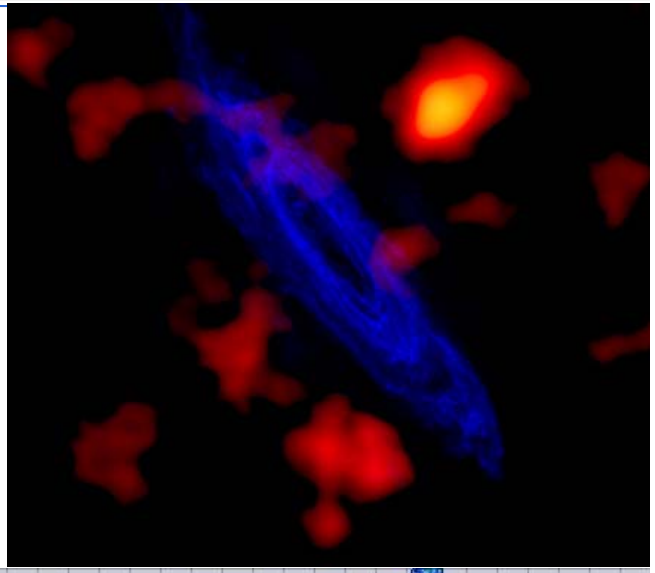

Spiral Galaxy M31
Hubble Space Telescope ▪ WFC3 ACS
HST WFC3 ACS
WIYN/KPNO 0.9m Mosaic 1
HST WFC3 ACS
NASA, ESA, and B. Williams and J. Dalcanton (University of Washington, Seattle)
STScI-PRC12-03a

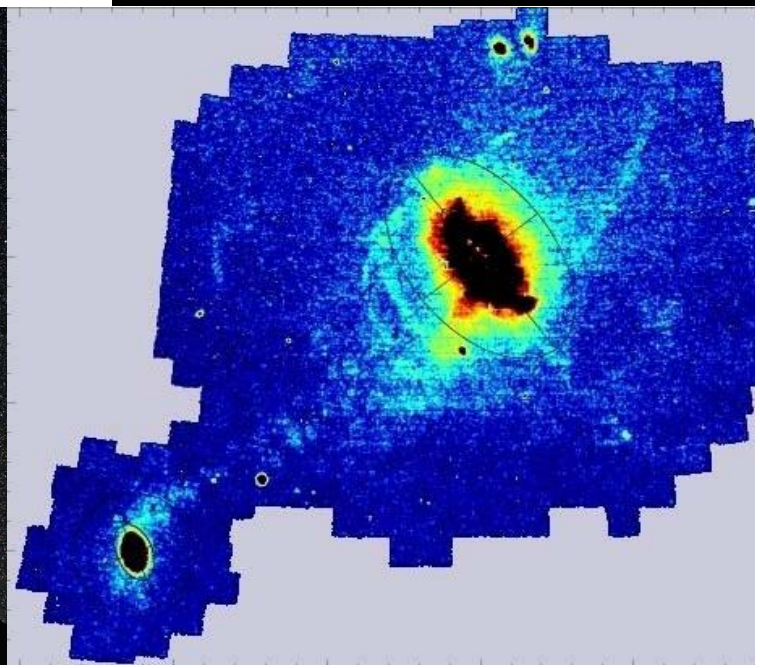

M31 Nucleus
Hubble Space Telescope • ACS/HRC
HST ACS/HRC
WIYN/KPNO 0.9m Mosaic I
NASA, ESA, and T. Lauer (NOAO)
STScI-PRC12-04a


Optical
Infrared
Composite
Infrared & X-rays
X-rays

M31 as part of the Local Group

- Disk of M31 asymmetric
- Distribution of HI clouds in halo
- Interaction with M33
  - Role of M32 and NGC205?
- Future interaction with MW





This Conference

- Martin's interest included stars, stellar populations, dynamics and high-resolution observations
- He studied M31 at various times in his career
- Timely and appropriate to celebrate the Centenary:
  - Review much of the recent work on M31
    - Observational information is tremendous: this spiral galaxy can be studied in its entirety with excellent resolution
  - Pay tribute to main achievements of one of the most influential astronomers of the past century