Panel B, Chapter 3

How Do Galaxies Form and Evolve?

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- Conclusions

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Comments and Parallel Session: General

- General satisfaction with key science questions, opportunities, and objectives
- Several areas for additional objectives or enhanced emphasis identified
- Major revision to facilties recommendation needed (IR telescope)

Scientific Opportunities

- Co-Evolution of Galaxies and Central Black Holes *(G. Hasinger)*
  - importance of black hole formation and growth in galaxy formation/evolution should be amplified
  - future X-ray, radio continuum facilities will provide samples of very early black holes (order 10^6 M_o) to trace co-evolution
  - broadened Fe K line detectable to z>6
  - emphasize the value of resolving the cosmic backgrounds for understanding early evolution

Scientific Opportunities

- The starburst/AGN connection via IR spectroscopy, imaging (*L. Spignolio*)
  - Future far-infrared interferometer will resolve dusty nuclei from circumnuclear disks at high redshift
  - Large-aperture (>10m) IR telescope enables Spitzer-quality spectroscopy of nuclei at high redshift
  - Key scientific need is 10-20m aperture far-infrared telescope and/or interferometer (ground or space, discussed later)

Scientific Opportunities

- **Evolution of the Cosmic Web**
  (V. D'Odorico, W. Hermsen)
  - visible/infrared absorption line spectroscopy of paired/multiple sightlines
    - arcsecond separations possible with ELT
    - trace correlation of metallicity and structure
  - OVI and OVII gas can be traced in emission to map warm/hot phase at low redshift

Scientific Opportunities

- Dark Matter and Dynamics of Nearby Galaxies *(G. Gilmore, F. Hammer)*
  - ELT multiplex spectroscopy of individual stars, clusters will allow mapping of dark halo structures to Virgo cluster
  - studies of emission-line, CO, and HI kinematics of galaxies valuable even for z < 2

Scientific Opportunities

- Properties and Physics of Star Formation, ISM, IMF in Nearby Galaxies
  (J. Braine, B. Brandl, F. Hammer, F. Boulanger)
  - new facilities such as ALMA, SKA, ELT, etc will provide breakthrough capabilities in studying star formation in nearby galaxies on the scale of individual clusters/starbursts
  - a comprehensive suite of diagnostic features will be accessible (HI, ^{12}CO, ^{13}CO, C^+, O^0, N^+, PAH, H_2, HI, PDR lines, Hα…)
  - Key goal is to calibrate accurate diagnostics (e.g., of H_2 column density)
  - coordinated samples, probing range of metallicity, interstellar pressure

Scientific Opportunities

- **Magnetic Fields** *(R. Beck)*
  - play a key role across range of problems in this chapter
  - low-frequency radio telescopes (LOFAR) offer especially powerful promise for measuring fields via polarization, Faraday rotation
  - roadmapping might include feasibility assessment for key experiments (e.g., measurement of intergalactic fields)

Scientific Opportunities

- Stellar Physics from Galactic/Extragalactic Studies *(A. Korn, P. Groot)*
  - data offer important inputs for testing stellar models
  - understanding of binary populations vs metallicity, etc important for understanding SN projenitors, X-ray binaries and IMBHs, and LISA foregrounds
  - full exploitation of Gaia will require a major program of multiplex stellar spectroscopy, perhaps with dedicated 4-8m telescope(s), in advance of mission completion

Facility Recommendations

- UV-Optimized 4-8m Space Telescope
  - strong support voiced in parallel session
- Large Infrared Telescope
  - draft recommendation for cold 4-8m space telescope should be revised
    - biggest science gains in this area will come with larger aperture (10-20m)
    - roadmap should address relative cost/benefit merits of aperture, and ground (South Pole?) vs space telescope, and cooling requirements, in context of current/planned facilities (JWST, APEX, CCAT, ALMA, etc)
    - infrared interferometer remains a long-range priority, but also evaluate merits of ground vs space

Facility Recommendations

- **Survey Telescopes** (*I. Eglitis, others*)
  - many survey facilities contemplated (X-rays, OVII/OVIII, H_2, groundbased wide-field synoptic, spectroscopic telescopes)
  - key area of need identified for highly multiplexed spectroscopy in visible and/or near-infrared, with wide-field 4-8m telescope(s)
  - some programs rely on planned US survey telescopes (PanStars, LSST)