Paper PI	Title	Science Topics	Passband	Wavelength / Freq.	Aperture	Instrument	Spectral Res.	Angular Res.	Field of View	Sensitivity	N(pixels)	T(Tel)	T(Instr.)	Orbit	Mass	LV	Cost	Basis	Technology
C.M. Bradford (JPL/Caltech)	A Probe-Class Opportunity for Far-IR Space Astrophysics		FIR	50-500 microns	2.5m	Spectrometer	R~500	N/A	N/A	4×10^{-10} W Hz$^{-1/2}$	20,000	4K	50-100 mK	S-E L2	3000 Kg	Falcon-9	~$1B FY08	Flagship Costing	moderate resolution grating-type dispersive spectrometers
		Directly chart the history of cosmic star formation, supermassive black hole growth, and baryons in the cosmic web by studying gas-phase cooling lines through the epochs of peak stellar and black-hole mass growth.																	
		Conduct a census of gas mass and conditions in protoplanetary disks throughout their evolutionary sequence.																	
		Measure clustering and total emission of faint galaxies below the individual detection threshold using tomo- graphic intensity mapping of the far-IR emission lines, particularly for the faint Epoch of Reionization galaxy populations.																	
		Probe the cycling of matter and energy in the Milky Way and nearby galaxies with sensitive spectral probes of the energetics of the atomic and molecular ISM.																	
J. Lazio (JPL)	PROBING THE DARK AGES AND COSMIC DAWN WITH NEUTRAL HYDROGEN		Radio	15-120 MHz	"small"	Spectrometer	0.5/0.1 MHz	5 deg/3'	2*pi Sr/10 sq deg	3/1 mK	N/A	Ambient	Ambient	Far side of the Moon	1000 Kg	N/A	<$1B	PSD analog	Detector and Signal Processing in the Radio
		Dark Ages ($z > 35$): Before the first stars formed, the gas is expected to have cooled rapidly relative to the CMB, causing the H I feature to appear in absorption.																	
		First Stars ($35 > z > 20$): After the first stars appeared, their UV radiation couples to the H I line through the Wouthuysen-Field effect.																	
		First Accreting Black Holes ($20 > z > 15$): Hot accretion disks around the first stellar remnants (e.g., black holes) emit X-rays, which efficiently heat the cold H I gas.																	
		Epoch of Reionization ($15 > z > 6$): Eventually, UV photons from stars and black holes started ionizing the gas in giant bubbles within the IGM.																	
M. Ulmer (Northwestern)	An orbiting wide-field x-ray imaging spectrometer (WFXIS)		X-ray	0.1-2.5 keV	N/A	Spectrometer	5eV	10'	80+ degrees	N/A	500x500	Ambient	Ambient	N/A	N/A	N/A	N/A	N/A	large format x-ray arrays
		clusters of galaxies, from those with sub-clumps to those at the edge of the universe																	
		individual galaxies																	
		deep sky surveys for clusters and QSO/AGN,																	
		supernova remnants (SNRs) in galaxies such as the LMC, SMC and Andromeda																	
		knots in galactic SNRs such as Cas-A																	
		the large scale structure of the ISM, nearby clusters of galaxies, and large SNRs, such as the Cygnus loop and the Vela/Puppis region.																	
M. Ulmer (Northwestern)	An all-sky low-energy gamma-ray observatory (ALLEGRO)		Gamma ray	7-200 keV	2000 cm^2 eff.	Spectrometer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Advances in electronics, computing power, and data storage and retrieval with high time resolution
		the understanding of gamma-ray bursts																	
		rotationally powered neutron stars																	
		binary x-ray sources																	
		monitor the hard x-ray sky, provide hard x-ray maps, and even provide a stringent test of the general relativistic Shapiro delay.																	
P. Roming (SWRI)	Death of Massive Stars (DoMaS) Probe		Soft X-ray/NIR/FUV	0.2-5keV / 0.7-2.5micron / 130-300nm	1m/1m/0.5m	Camera+spectrographs	R=40/1000/1000	1'/1"/1"	2.4Sr/30'/30'	1.6 x 10-11 erg cm-2 s-1 3.9x10-20 ergcm-2 s-1 Å-1 @1.6μm in 1s 2.4x10-17 ergcm-2 s-1 Å-1 @1700Å in 1s	N/A	N/A	N/A	GEO	N/A	N/A	$762M FY16	NICM	GaN MCP - all other @ TRL 6 already
		Nature of the First Stars and Their Contribution to Reionization																	

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	Nature and Death of Massive Star Progenitors																	
	Ancillary Targets - lower redshift sub-luminous, short, and long GRBs; thermonuclear bursts; flare stars; SNe Ia breakouts; superfast X-ray transients; classical no- vae; tidal disruption events; blazars; AGNs; soft γ-ray re- peater flares; and hot OB stars with winds																	
H.A. MacEwen (Reviresco LLC)	FORERUNNER for the EVOLVABLE SPACE TELESCOPE (ForEST)	UV-Vis-IR	N/A	4m	Mirror deployment	N/A	N/A	N/A	N/A	N/A	Ambient	Ambient	cislunar	5000 Kg	N/A	N/A	N/A	Modularized mirror deployment with a view to 10m+ telescopes in the future
	Pure Technology Paper																	
P.A. Scowen (ASU)	HORUS – THE HIGH ORBIT ULTRAVIOLET-VISIBLE SATELLITE	NUV-Visible / FUV	200-1075nm / 100-170nm	2.4m	Camera / Spectrograph	R=40,000	0.05"	14'	1 x 10-16 erg cm-2 s-1	64,000	Ambient	Ambient	ES-L2	N/A	Delta-IV	$1.28B FY17	Decadal 2010 study extrapolated	Large focal plane arrays, dichroics, MCPs - all TRL 5 or higher
	an imaging census of all high-mass star formation sites within 2.5 kpc of the Sun to determine how frequently solar systems form and survive																	
	Survey all major star forming regions in the Magellanic Clouds to sample star formation in an initial regime of low metallicity applicable to high-redshift galaxies.																	
	Extend the star formation survey to galaxies in the nearby universe in order to increase the range of galaxy interaction and metallicity environments probed.																	
	Measure star formation and metal production rates in the distant universe to determine how galaxies assemble																	
F.R. Hearty (Penn State U.)	Deep Survey Telescope: Exploring the First Billion Years	NIR/MIR	0.5-5 microns	4m	Camera	16 filter bands	0.2"/pixel	1.6 degrees	~27mag in 60 s	829 Gpix	70 K	70K	N/A	N/A	N/A	requires "breaking" of cost curve to fit inside $1B	N/A	Same as WFIRST-AFTA with emerging tech for other aspects
	How was large-scale baryonic structure assembled in the early Universe? DST will identify at high redshift: the first QSOs, the earliest massive galaxies and galaxy clusters, high redshift supernovae of all varieties																	
	DST will identify at low redshift: Host galaxy type and redshift for each supernova discovered by LSST, progenitor star for many future supernovae from Local Group to Virgo cluster, Tidal streams and halo structures for Local Group galaxies																	
	DST will identify in our Solar System: potentially hazardous asteroids, near-Earth asteroids down to 30m, planet (and dwarf planet) resident in Kuiper Belt, Inner Oort Cloud, and possibly Oort Cloud itself																	
S. Rinehart (GSFC)	The Space High-Angular Resolution Probe for the InfraRed (SHARP-IR)	FIR	20-160 microns	12m baseline	Interferometer	N/A	0.3-2.75"	N/A	N/A	N/A	Ambient	4K	N/A	N/A	N/A	>MIDEX	SPIRIT & FKSI experience	Detector development needed - all else already proven
	to observe crucial atoms, ions, and molecules such as water as well as continuum sources																	
	to enable discoveries in the areas of star and planet formation, AGN, obscured star forming galaxies at high redshifts, cool objects in general, and the outer solar system																	
P.A. Scowen (ASU)	ORION UV-VISIBLE PROBE	NUV-Visible	200-1100nm	1.2m	Camera	12 filter channels	0.1"/pixel	14'	1 x 10-16 erg cm-2 s-1	64,000	Ambient	Ambient	ES-L2	N/A	N/A	$358M FY17	Two Team-X studies	Large focal plane, technologies TRL 5 or higher
	an imaging census of all high-mass star formation sites within 2.5 kpc of the Sun to determine how frequently solar systems form and survive																	
	Survey all major star forming regions in the Magellanic Clouds to sample star formation in an initial regime of low metallicity applicable to high-redshift galaxies.																	
	Extend the star formation survey to galaxies in the nearby universe in order to increase the range of galaxy interaction and metallicity environments probed.																	
A. Cooray (UC Irvine)	Cosmic Dawn Intensity Mapper	IR	0.7-7 microns	1.5m	Spectroscopic Imager	R=200-300	1"/pixel	10 sq deg	1 x 10-18 erg cm-2 s-1	129 Gpix	N/A	N/A	N/A	N/A	N/A	$850M	ESA M5 proposal	HgCdTe detectors & linear variable filters
	pioneering observations of the Lyman-α, Hα and other spectral lines of interest throughout the cosmic history, but especially from the first generation of distant, faint galaxies																	
	produce a three- dimensional tomographic view of the epoch of reionization (EoR), mapping Lyα emission from galaxies and the intergalactic medium (IGM)																	
	map out, for example, Hα emission from z=0.2 to reionization, providing a three-dimensional view of the star-formation history, its environmental dependence, and clustering over 90% of the age of the Universe																	

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S. Heap (Eureka Scientific)	Galaxy Evolution Spectroscopic Probe (GESP)	NUV / NIR	200-400nm / 800-1600nm	1.5m	MOS	R~500	Adjustable slits	0.03-0.08 sq deg	2x10-18 ergcm-2 s-1 Å-1	243 slits	Ambient	Ambient	N/A	N/A	N/A	<$1B	"design to cost" approach	slit generator, convex grating
	GESP will study the physics of the ISM, accretion and star formation, stellar feedback, and galactic winds																	
	GESP will answer: what are the roles of stellar feedback, AGN feedback, and dark energy in driving galaxy evolution																	
M. Robberto (STScI)	A Near-IR All-Sky Spectroscopic Probe	NIR	0.8-1.8 microns	1.5m	Slit selector + spectrograph	R~400	0.75" slits	0.4 sq deg	AB~23 mag in 15 mins	N/A	Ambient	Ambient	N/A	N/A	N/A	<$1B	previous ESA small mission proposal	DMD @ TRL 6
	to perform the most accurate measurement of the expansion history of the Universe (using baryonic acoustic oscillations) and the growth history of cosmic large scale structure (using redshift space distortions), measuring the redshifts of ~500 million galaxies regardless on their spectral type and environment																	
	to understand galaxy build-up and evolution by analyzing the detailed information contained in the same spectra																	
C.K. Walker (U. Arizona)	Terahertz Space Telescope	THz	30-300 microns	20m inflated	Coherent cameras	R~10^3-10^6	0.4-4"	N/A	~1x10-18watt/Hz1/2	N/A	Ambient	4-6K	N/A	600 Kg	N/A	<$750M	unclear	inflatable spherical reflector, THz detectors
	Star formation through cosmic time																	
	• Galaxy formation and evolution: from quasars, Seyferts, and starbursts to the Milky Way																	
	• Life cycle of the interstellar medium																	
	• Galactic ecology																	
	• Astrochemistry																	
	• Formation of solar systems: debris disks, protoplanetary evolution, Kuiper Belt objects, asteroids and comets, planetary atmospheres																	
M. Ulmer (Northwestern)	The Next Generation Space UV-Vis Space Observatory (NG-SUVO)	UV-Visible	350-10000nm	2.4m	Camera	Filters	0.03"	6'	unclear	N/A	Ambient	Ambient	N/A	N/A	N/A	$2B FY17	Descope of 2009 paper estimate	improvements in optics (coatings) and detectors
	1. A study of the hot intracluster medium of rich clusters of galaxies																	
	2. He II absorption and the ionization history of the Universe out to z of 4.																	
	3. Observing metals in intergalactic filaments																	
	4. Observing the warm hot intergalactic medium (WHIM) and the relationship between galactic winds and metal enrichment of the WHIM.																	
	5. Detecting metals in planetary disks leading toward an understanding the relationship between the metallicity in proto-planetary disks and planet formation.																	
	6. Detecting the water absorption and perhaps even DNA-protein-like absorption features in the atmospheres of extra-solar planets (or extra-solar moons such as Europa or Enceladus).																	
	7. Imaging aurorae on solar system planets, e.g. Jupiter																	
P. Goldsmith (JPL)	SPECtroscopic TeRAhertz Satellite "SPECTRAS"	THz	300-5000 GHz	6m	Spectroscope	low-res	4-25"	256-1600"	4x better than Herschel	5x64	5-10K	4K	ES-L2	<7000 Kg	Falcon9H	$1.4B	Team X	THz detectors derived from Herschel
	will target the most important low-lying transitions of both HDO and other isotopologues of water, enabling accurate measurements of the D/H and oxygen isotopic ratios in a large number (on the order of 20) of comets																	
	water will be a uniquely powerful tracer of the collapse of dense star-forming cores																	
	SPECTRAS's higher sensitivity it will possible to survey many nearby disks and determine their gas-phase water content																	
	Atomic fine structure lines are valuable probes of the interstellar medium and star formation																	