Spitzer Space Telescope - General Observer Proposal #60071

A Comprehensive Study of Dust Formation in Type II SNe with HST, SST, and Gemini

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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Requested: 6.3
Proprietary Period: 365

Abstract:
Recent detections of large amounts of dust in high redshift galaxies imply that Type II supernovae (SNe) may be important dust contributors. The dust in high-z galaxies must come from young, massive stars, so Type II SNe are one of the few possible sources. We propose to continue monitoring of four nearby Type II SNe: 2004et, 2007it, 2007oc, and 2007od, in order to study dust formation in the ejecta of Type II SNe. The three observational signatures of this dust formation include, a decrease in the continuum brightness in the visible, a developing infrared excess, and asymmetric, blue-shifted emission-line profiles. With Spitzer, we will be able to carefully study the IR emission, and put strong constraints on the dust mass and how the dust changes with time. The proposed observations will be combined with previous epochs of Spitzer data and coordinated, already approved Gemini and HST observations. We may be able to double the number of Type II SNe known to have shown all three dust formation signatures. This increased sample size will help us to better understand what fraction of Type II SNe produce dust, how much dust they produce, and how conditions in the SNe ejecta affect the dust formation. These estimates will help us to deduce whether Type II SNe can be a major source of dust in young, high redshift galaxies.



Spitzer Space Telescope - General Observer Proposal #60116

Extended Stellar Distributions in M83

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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Requested: 30.0
Proprietary Period: 365

Abstract:
The outer disks of galaxies provide a unique environment for studies of disk growth and galaxy formation. Due to the long dynamical timescales in the outer disk, stellar structures such as breaks, truncations, and tidal streams persist over billions of years. Deep imaging of these structures allows us to trace the history of the galaxy's accretion events and evolution, thus providing essential constraints on current models of galaxy formation. Here we are proposing for deep IRAC imaging of the prototypical star-forming galaxy, M83, to conduct a pilot study for a larger survey of the outer disk of nearby galaxies. M83 has a rich set of ancillary data that will allow for a multiwavelength analysis of the stellar populations throughout the outer disk. Existing ACS data will allow for a direct calibration of the observed IR surface brightness to a stellar mass density. Comparison of deep IR and UV integrated light profiles will reveal variations in the stellar populations and provide a unique test case for models of disk growth.

Spitzer Space Telescope - General Observer Proposal #60072

The 3.6 micron Surface Brightness Profiles of Outer Disks: NGC 4625 and M 83

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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Requested: 5.6
Proprietary Period: 365

Abstract:
The outer regions of galactic disks have been a topic of increased interest since ultraviolet observations with the GALEX observatory demonstrated that nearly 30% of galaxies show extended UV emission and star formation, tracing to well beyond the optical radius (R25). Although young stellar populations in these disks are being studied intensively in the UV and H-alpha, very little is known about the older stellar population of outer disks. We request 16.8 hours to image the outskirts of two prototype 'XUV' (extended UV emission) galaxies, with sufficient depth and field coverage to measure their 3.6 micron profiles. Using these profiles we will derive radial stellar mass profiles, UV-IR color profiles, and gas fraction profiles. These will allow us to address several critical questions about the formation and evolution of these outer disks and the host galaxies themselves.



Spitzer Space Telescope - General Observer Proposal #60088

Spitzer/IRAC Study of Stellar Streams Around Nearby Galaxies

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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Requested: 23.1
Proprietary Period: 365

Abstract:
Minor mergers and satellite accretion events have the ability to dramatically change the appearance of the parent galaxy and even cause substantial evolution from bulgeless galaxies toward early-type disk galaxies and ellipticals. They also presumably take place at a much higher frequency than the more spectacular major mergers. We propose to characterize the stellar populations of extragalactic tidal stellar streams with ultra-deep IRAC channel 1 observations . These observations take advantage of IRAC's unique capability to detect extended, faint surface brightness emission, and will push IRAC to new frontiers. We seek to observe two edge-on disk galaxies which have known visible light stellar streams, and determine the visible light - infrared colors of the streams. This will help us to determine the structural types and stellar masses of the disrupted companion galaxies, which has immediate significance on the understanding of bulge formation, halo build-up and numerous other important topics that have been proposed to occur with the help of minor mergers. We ask for a total of 23.1 hours of observing time with IRAC.

Spitzer Space Telescope - General Observer Proposal #60007

The Spitzer Survey of Stellar Structure in Galaxies (S4G)

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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Requested: 637.2
Proprietary Period: 0

Abstract:
We propose the ultimate survey of the distribution of stellar structure in the nearby universe using IRAC's 3.6 and 4.5 micron channels. Deep observations of the stellar mass distribution, down to 0.1 Msun per sq. pc for a sample of ~2,300 nearby (d<40Mpc) galaxies, will provide an unprecedented dataset for studies of structure formation during galaxy evolution. Such observations will provide answers to some of the most fundamental questions of our field: how are outer disks and halos formed? how do galaxy interactions affect the formation and evolution of galactic structures? which structural parameters govern internal galaxy evolution? Our large unbiased sample of all Hubble types ranging from dwarfs to spirals to ellipticals will allow for such structural studies, not only as a function of stellar mass, but also as a function of environment, and the output of such an immense survey will serve as a vital testbed for cosmological simulations predicting the mass properties of present-day galaxies.



Spitzer Space Telescope - General Observer Proposal #60094

Faint Stellar Distributions in Extended HI Disks

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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Requested: 69.6
Proprietary Period: 365

Abstract:
In Lambda-CDM models, galactic disks are built through the accretion of small satellites and through in situ star formation activity. We propose to obtain deep observations with IRAC bands 1 and 2 to trace the faint extended stellar component of nearby gas-rich galaxies in order to investigate models of galactic disk formation and growth. While little is currently known about the full spatial extent of the stellar component within a dark matter halo, we have identified a sample of 5 gas-rich galaxies with extremely large HI disks (D_HI/D_opt > 5) as being the most likely candidates to harbor extended faint stellar populations. The proposed deep IR observations will allow us to trace their stellar distributions to unprecedented levels at wavelengths that are insensitive to both dust extinction and the galaxy's star formation history. Because our observations are exploratory in nature, we also propose observations of a control sample of 4 gas-rich galaxies with normal HI distributions (D_HI/D_opt ~ 2) in order to investigate the extent and nature of faint stellar populations in the outer disks of galaxies. Comparison of the observed IR surface brightness profiles with multiwavelength data (from UV to radio) will reveal the characteristics of the extended disk and provide insight into disk growth and evolution of gas-rich galaxies.

Spitzer Space Telescope - General Observer Proposal #60034

The IRAC Lensing Survey: Achieving JWST depth with Spitzer

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 526.4
Proprietary Period: 0

Abstract:
Massive clusters of galaxies are now recognized as very effective 'cosmic telescopes'. Because of the gravitational lensing effect, they can amplify significantly the background sources - by factors of a few tens - thereby bringing into view faint sources that would otherwise be unobservable. Note that in the background-limited case, which is applicable to IRAC observations, a factor of 20-30 gravitational amplification translates into increasing the integration time by a factor of 400-900. Because of this tremendous gain in sensitivity, IRAC imaging of lensing clusters will allow us to achieve JWST depth (~10 nJy) with Spitzer. Despite this great possibility, however, the full potential of the lensing cluster technique has not yet been realized due to the small number of clusters that have well-constrained accurate mass models. Here, we propose to conduct an IRAC imaging survey of 47 massive lensing clusters (5 hours/band, 2 bands) for which we have constructed accurate mass models through many years of intensive imaging/spectroscopic campaigns with HST, Keck, and VLT telescopes. This is the first time when such a large, statistical sample of clusters will be systematically employed to probe high-redshift Universe, and this proposed IRAC survey is a key component of our comprehensive program, which includes HST/WFC3 and Herschel observations starting next year. Scientifically, we will use the obtained IRAC data to (1) characterize z>6 galaxies (expecting ~50 z~7-8 galaxy detections), (2) support future Herschel and ALMA surveys, and (3) search for z>6 supernovae. The resultant data set will be a great legacy of Spitzer, allowing us to start tackling JWST sciences well before its launch.



Spitzer Space Telescope - General Observer Proposal #60022

SEDS: The Spitzer Extended Deep Survey

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 2108.0
Proprietary Period: 0

Abstract:
The Spitzer Extended Deep Survey (SEDS) will provide a unique opportunity to obtain the first complete census of the assembly of stellar mass and black holes as a function of cosmic time back to the era of reionization, yielding unique information on galaxy formation in the early Universe. The survey will also

measure galaxy clustering over a wide redshift range, which will provide the critical link between galaxies and their dark matter halos and critical tests of models of early star formation. SEDS will achieve these goals by tracing the stellar mass growth in mass-selected samples of galaxies via their broadband spectral energy distributions. The baseline proposal is an unbiased survey with 12 hours/pointing at 3.6 and 4.5 microns over five well-studied fields of 0.90 square degree total. We expect to find (a) >10,000 galaxies at z = 4--6 (including ~1000 galaxies at z = 6), reaching galaxies down to ~5 x 10^9 Msun at z = 6, necessary to robustly measure M* at that redshift, i.e., the galaxies that dominate the global stellar mass density, and (b) >100 massive galaxies at z = 7, which will firmly anchor the high mass end of the early galaxy populations and provide targets bright enough for future spectroscopic follow-up with 20--30 meter telescopes, JWST, and ALMA. The proposed five-field deep survey will enable several secondary science objectives. These include: (1) galaxy evolution in the redshift range z ~ 1--4, (2) AGN variability, and (3) measurement of the cosmic infrared background spatial fluctuations. SEDS is the most efficient and most highly optimized program that we can imagine to achieve core scientific goals of the warm mission. The opportunity to probe the Universe so widely and at such a depth at mid-IR wavelengths will not come again in the foreseeable future. SEDS is a unique program that will leave an important legacy for years to come.



Spitzer Space Telescope - General Observer Proposal #60158

Two Lensed Ly-A Emitters at z ~ 5

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 1.8
Proprietary Period: 365

Abstract:
We propose 3.6 micron imaging of two newly discovered Ly-A emitters at z=5.0 and 5.2. These spectroscopically confirmed sources, located behind a pair of strong lensing clusters from the SDSS Giant Arcs Survey, are lensed and appear an order of magnitude brighter than the small samples of typical Ly-A emitters previously found at high redshifts in ultra-deep fields. As such they offer the opportunity for detailed individual study which these other sources do not, and can be well measured in modest (less than 1 hour) total integrations. The proposed observation provides a critical measure of the presence or absence of older stars in these objects, and hence helps constrain stellar mass, and in conjunction with ground-based near-IR imaging will yield a detailed picture of the spectral energy distribution of these sources from rest-frame UV to optical wavelengths.

Spitzer Space Telescope - General Observer Proposal #60024

SERVS: the Spitzer Extragalactic Representative Volume Survey

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 1400.0
Proprietary Period: 0

Abstract:
We will use warm Spitzer to image 18deg^2 of sky to microJy depth. This is deep enough to undertake a complete census of massive galaxies from z~6 to ~1 in a volume ~0.8Gpc^3, large enough to overcome the effects of cosmic variance, which place severe limitations on the conclusions that can be drawn from smaller



fields. We will greatly enhance the diagnostic power of the Spitzer data by performing most of this survey in the region covered by the near-IR VISTA-VIDEO survey, and in other areas covered by near-IR, Herschel and SCUBA2 surveys. We will build complete near-infrared spectral energy distributions using the superb datasets from VIDEO, in conjunction with our Spitzer data, to derive accurate photometric redshifts and the key properties of stellar mass and star formation rates for a large sample of high-z galaxies. Obscured star formation rates and dust-shrouded BH growth phases will be uncovered by combining the Spitzer data with the Herschel and SCUBA2 surveys. We will thus build a complete picture of the formation of massive galaxies from z~6, where only about 1% of the stars in massive galaxies have formed, to z~1 where ~50% of them have. Our large volume will allow us to also find examples of rare objects such as high-z quasars (~10-100 at z>6.5), high-z galaxy clusters (~20 at z>1.5 with dark halo masses >10^14 solar masses), and evaluate how quasar activity and galaxy environment affect star formation. This survey makes nearly optimal use of warm Spitzer; (a) all of the complementary data is either taken or will be taken in the very near future, and will be immediately publicly accessible, (b) the slew overheads are relatively small, (c) the observations are deep enough to detect high redshift galaxies but not so deep that source confusion reduces the effective survey area.

Spitzer Space Telescope - General Observer Proposal #60059

Are the brightest Lyman Alpha Emitters at z=5.7 primeval galaxies?

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 11.2
Proprietary Period: 365

Abstract:
Wide-field, narrow-band surveys have proven to be effective at finding very high redshift galaxies that emit brightly in the Lyman alpha line - the so-called Lyman alpha emitters (LAEs). It was through this technique that the most distant spectroscopically confirmed galaxy, a galaxy at z=6.96 (Iye et al. 2006), was discovered. Considerable effort is currently being spent on discovering these galaxies at ever higher redshifts by extending this technique into the near-IR. In contrast to this effort, there has been relatively little work on understanding these galaxies. In particular, how do LAEs relate to other high redshift galaxies, such as those discovered through drop out techniques, and, more importantly, what role LAEs play in re-ionising the universe, if any. We recently discovered two extremely luminous LAEs at z=5.7. These LAEs are among the brightest LAEs ever discovered at this redshift. In a recent paper by Mao et al. (2007), the brightest LAEs are associated to the most massive halos. One of these targets was successfully observed with the IRAC 3.6 micron imager on Spitzer during cycle 5. These data, when combined with constraints that we derive from our deep ground-based spectroscopic data, indicate that the bulk of the flux at 3.6 microns comes from a stellar population that is considserably older than the stars that dominate the flux in the UV. We propose to complete the project and image the second target. These data will enable us to estimate the age and mass of the stellar burst that produces the Lyman alpha line, to estimate the contribution from an older stellar population and to estimate the fraction of Lyman continuum photons that escape the galaxy and are thus available to re-ionise the universe.



Spitzer Space Telescope - General Observer Proposal #60147

Gas without stars? Elucidating the nature of a highly unusual CO line emitter in the early universe.

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 2.2
Proprietary Period: 365

Abstract:
We propose to obtain deep IRAC photometry at 3.6um to investigate the nature of a highly peculiar, luminous CO line emitter which does not appear to be associated with a significant stellar mass. TXS0828+193 SW1/2 is in the halo of the powerful radio galaxy (HzRG) TXS0828+193 at redshift z~2.6, at a radial distance of 85 kpc from the radio galaxy and near the hot spot of the radio jet. The CO(3-2) emission line luminosity of SW1/2 corresponds to a total mass of about 2x 10^10 M_sun in cold molecular gas, similar to that of strongly star-forming, massive submillimeter galaxies at similar redshifts. . Intriguingly, we do not find a counterpart at rest-frame UV to mid-infrared wavelengths, which suggests a much lower stellar mass of <few x10^9 M_sun and low star-formation rates. We propose two scenarios for the nature of this enigmatic source: (1) The gas may either be associated with an exceedlingly gas-rich, low-mass galaxy unlike any other high-redshift galaxy previously detected in CO. (2) The molecular gas may represent a cloud or filament in the gaseous halo surrounding the radio galaxy, and may be influenced by the nearby radio jet. In either case, the discovery of SW1/2 has the potential to significantly deepen our understanding of the role of molecular gas at high redshift. The proposed IRAC imaging is part of an extensive program of follow-up observations in different wavebands. SW1/2 is likely to be highly dust-enshrouded, and thus, our stellar mass limit may not be ideal. The main goal of the proposed observations is thus to obtain tighter and more robust limits on the stellar mass of SW1/2, which is obviously a critical aspect in elucidating the nature of this mysterious object.

Spitzer Space Telescope - General Observer Proposal #60177

Direct Stellar Mass Determinations for Individual Lyman Alpha Emitters at z~2

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 21.4
Proprietary Period: 365

Abstract:
We propose to obtain deep IRAC 3.6 micron imaging of fields where we have conducted a survey of low redshift (z~1.9) Lyman-alpha emitters (LAEs), in order to measure directly their individual stellar masses. The targeted sample includes ~25 spectroscopically-confirmed LAEs at z=1.7-2.1 and roughly twice as many candidates, for a total sample size of ~75 objects. This would constitute perhaps the largest sample of homogeneously selected LAEs with individual measurements of their masses, allowing for a unique opportunity to correlate such measurements with other galaxy properties. In particular, the proposed imaging enables us to quantify the actual stellar mass distribution in of LAEs (as opposed to a stacked average) and, using these data, we will (1) determine whether stellar mass anti-correlates with Lyman-alpha emission, suggesting that Ly-alpha may be a signpost of young galaxies; (2) combine clustering and stellar mass measurements to infer duty cycles of LAEs and if they are triggered in the presence of larger scale structures; (3) combine number density and stellar masses to infer a stellar mass function of LAEs, which when compared with the mass function of all galaxies will shed new light on the importance of the LAE phase at different galaxy mass scales; and (4) quantify the ages of LAEs as inferred from the stellar mass and star formation rate measurements to ascertain the age distribution of low-z LAEs and compare with their higher redshift (z>3) counterparts, and compare the ages to the duty cycles of LAEs. IRAC imaging is a unique tool to pursue these investigations since 3.6 micron samples the peak of the stellar continuum and is less contaminated by current star formation at z~1.9 than at z>3 (where almost all studies have been focused). Thus, a first step to understanding the physical properties of LAEs as function of cosmic time hinges on our ability to rigorously investigate their nature at lower redshifts where the observations are more amenable.



Spitzer Space Telescope - General Observer Proposal #60176

The Spitzer Lyman Alpha Survey

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 91.1
Proprietary Period: 365

Abstract:
Determining the star formation history of high-redshift galaxies is vital for understanding galaxy formation and reionization. These galaxies are typically selected using their rest-frame ultraviolet (UV) fluxes, thus their old stellar populations can be missed. Spitzer Imaging at 3.6 microns is essential to measure the rest-frame optical fluxes of high redshift galaxies and therefore estimate the total stellar mass. Lyman-alpha galaxies form fully half of the known galaxies at z=3-6. The strength of the Lyman-alpha line, at first glance, indicates a young (~10 million years old) and dust-free population. This picture of Lyman-alpha galaxies as a class of less massive and young objects is simultaneously being confirmed and challenged thanks to Spitzer data. While most of the Lyman-alpha galaxies are young and low-mass, a subset of them are more massive and/or dusty. That there may be two types of Lyman-alpha emitters, is based on the only those few studies that analyze individual galaxies, and not co-addition of a sample of non-detections. In order to robustly investigate the statistical fraction of older and younger Lyman-alpha galaxies at any given redshift and to find out the redshift evolution of this fraction, we simultaneously need a large sample at many redshifts, and we need deep imaging so we can study individual objects. We propose a systematic IRAC 3.6 imaging survey of a spectroscopically confirmed sample of about 100 Lyman-alpha galaxies between redshifts 3.1<z<6.6. Deep broad-band imaging of all the galaxies in B,V,R,I and Z; and J and H imaging of a subset with NICMOS already exists. By fitting Spectral energy distributions we will measure accurately (1) The total stellar mass in these objects, including old stars which may have formed at redshifts > 8; (2) The dust extinction in the UV, and therefore a correction to their present star-formation rates; (3) The fraction of galaxies with old stellar populations as a function of redshift.

Spitzer Space Telescope - General Observer Proposal #60180

Deep IRAC Imaging of 24-micron Only Sources: Constraining the SEDs

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 16.8
Proprietary Period: 365

Abstract:
We request 17 hours for deep 3.6 micron IRAC observations of three extraordinary objects that are very bright at 24 microns, but are undetected at all other Spitzer, optical, or near-infrared wavelengths. Found in the widest of the extragalactic areal surveys (SWIRE; 45 square degrees) these are the only such objects found by Spitzer. Followup infrared spectroscopy centered on the 24-micron band indicates that at least two of the objects are extragalactic in nature and lie near a redshift of 2.5. However, the photometric non-detections are not compatible with the spectral energy distribution (SED) of any known class of objects. The new Spitzer data will lower the detection limits by an order of magnitude relative to the existing data, providing much stronger limits on the rest-frame near-IR luminosity.



Spitzer Space Telescope - General Observer Proposal #60145

Massive Galaxy Formation: Testing the AGN Feedback Hypothesis

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Science Category: high-z galaxies (z>0.5)
Target of Opportunity: Yes
Observing Modes: IracPostCryoMap
Hours Requested: 18.4
Proprietary Period: 365

Abstract:
Ad hoc prescriptions of feedback from an active galactic nucleus (AGN) are widely adopted in theoretical models of massive galaxy formation in order to efficiently quench the merger-induced starburst and growth of the supermassive black hole. Remarkably, however, observational evidence that AGN feedback is necessary for quenching star formation is conspicuously lacking. To address this fundamental problem, we propose to measure the stellar masses and burst mass fractions of an extraordinary sample of massive galaxies at z=0.4-0.8 that show evidence for large-scale outflows of cold gas, and whose last recent star formation episode was abruptly truncated. These measurements will establish whether the mechanical energy provided by supernovae and young stars in the last starburst is sufficient for driving the supergalactic wind, and therefore whether AGN feedback played an energetically important role for the formation of massive galaxies at intermediate redshift.

Spitzer Space Telescope - General Observer Proposal #60194

High-Redshift Sub-Millimeter Galaxies

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Requested: 55.4
Proprietary Period: 365

Abstract:
We propose to obtain IRAC imaging of 40 rare millimeter sources discovered by the South Pole Telescope (SPT). These sources are the observably brightest, rarest members of the population commonly referred to as sub-millimeter galaxies (SMGs) and will provide a new window on galaxy formation in the early universe. Because our targets are selected at longer wavelengths than typical SMG surveys, and are an order of magnitude brighter than the typical SMGs, they are expected to have a higher median redshift than objects currently in the literature. Simulations suggest that we are detecting a significant number of lensed sources, some of which should lie at z>6. The proposed observations, when combined with precise positions from ATCA 3 mm interferometric images, will enable photometric redshifts and measurements of total luminosity, star formation rates, and stellar masses for this unique sample of galaxies.



Spitzer Space Telescope - General Observer Proposal #60010

The Hubble Constant

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Science Category: cosmology
Observing Modes: IracPostCryoMap
Hours Requested: 705.0
Proprietary Period: 90

Abstract:
We present a plan to measure a value of the Hubble constant having a final systematic uncertainty of only 3% by taking advantage of Spitzer's unique mid-infrared capabilities. This involves using IRAC to undertake a fundamental recalibration of the Cepheid distance scale and progressively moving it out to pure Hubble flow by an application of a revised mid-IR Tully-Fisher relation. The calibration and application, in one coherent and self-consistent program, will go continuously from distances of parsecs to several hundred megaparsecs. It will provide a first-ever mid-IR calibration of Cepheids in the Milky Way, LMC and Key Project spiral galaxies and a first-ever measurement and calibration of the TF relation at mid- infrared wavelengths, and finally a calibration of Type Ia SNe. Most importantly this program will be undertaken with a single instrument, on a single telescope, working exclusively at mid-infrared wavelengths that are far removed from the obscuring effects of dust extinction. Using Spitzer in this focused way will effectively eliminate all of the major systematics in the Cepheid and TF distance scales that have been the limiting factors in all previous applications, including the HST Key Project. By executing this program, based exclusively on Spitzer data, we will deliver a value of the Hubble constant, having a statistical precision better than +/-1%, with all currently known systematics quantified and constrained to a level of less than 3%. A value of Ho determined to this level of systematic accuracy is required for up-coming cosmology experiments, including Planck. A more accurate value of the Hubble constant will directly result in other contingently measured cosmological parameters (e.g., Omega_m, Omega_L, & w) having their covariant uncertainties reduced significantly now. Any further improvements using this route will have to await JWST, for which this study is designed to provide a lasting and solid foundation, and ultimately a value of Ho accurate to 2%.

Spitzer Space Telescope - General Observer Proposal #60121

Cadenced IRAC Monitoring of Infrared-Variable AGNs, Part III

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Science Category: AGN/quasars/radio galaxies
Observing Modes: IracPostCryoMap
Hours Requested: 8.0
Proprietary Period: 365

Abstract:
We have analyzed IRAC imaging data from all 109 Spitzer visits to a very well-studied field, the IRAC Dark Calibration Field (IRAC-CF) near the north ecliptic pole. With this extensive dataset, we have already identified a unique sample of 30 IR-variable galaxies for which we are now working to characterize the variability amplitudes and timescales, panchromatic SEDs, and host morphologies, among other quantities. Unfortunately, the continual change in spacecraft roll angle means that our sources are typically observed for at most six months at a time by both IRAC FOVs in succession -- in other words, the visibility windows are exactly out of phase. Thus the planned Cycle 6 IRAC calibration observations, without the additional coverage our proposal would provide, will present large, unavoidable gaps that frustrate the time-delay analysis we wish to perform on exactly the timescales known to be typical of active galaxies. Since 2007 July, we have carried out cadenced IRAC observations in synchrony with the IRAC-CF dark-calibration observations as part of our approved Cycle 4 and 5 programs. We propose to continue this unique AGN monitoring campaign into 2010. The resulting timelines (covering 2000 days thus far and expected to run ultimately to more than 2400 days), are a unique legacy of the Spitzer mission. This dataset, especially for the sizable unbiased AGN sample we now have, holds unique promise for measuring the colors and temperatures of IR-varying AGN, and will have much to say about the underlying physical models of the infrared AGN emission. Accordingly, we ask for just 8 h to gather IRAC photometry in the temporal gaps that would otherwise accrue in Cycle 6.



Spitzer Space Telescope - General Observer Proposal #60132

Enigmatic features in Centaurus A

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Science Category: AGN/quasars/radio galaxies
Observing Modes: IracPostCryoMap
Hours Requested: 10.9
Proprietary Period: 365

Abstract:
Centaurus A is the closest radio-bright active galaxy, and provides a detailed view of the physics of radio sources and their interaction with the surrounding interstellar and intergalactic gas. In our recent X-ray based work on Centaurus A we have found two surprising new results: that the shock feature around the inner SW radio lobe is a synchrotron rather than thermal gas structure; and that the northern jet generates X-ray bright knots of thermal emission as it enters the northern middle lobe. In these knots we see some evidence for associated star clusters. These unexpected discoveries have important implications for source physics. The broad-band energy output of the X-ray shock traces the population of relativistic particles and hence acceleration physics at the shock. The knots are evidence of interaction of radio jets with interstellar gas, and the subsequent injection of thermal matter into radio lobes. Here we propose a single AOR that will make 1-hour exposures of the shock feature and the X-ray bright knots in each band. This will constrain the spectral energy distribution of the shock, and measure the IR properties of the dissipating gas clouds and embedded stars in the X-ray knots, comparing the properties of these clouds with HI clouds which appear not yet to have interacted with the jet.

Spitzer Space Telescope - General Observer Proposal #60139

Leveraging Spitzer's Legacy: Quasars and Feedback at High Redshift

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Science Category: AGN/quasars/radio galaxies
Observing Modes: IracPostCryoMap
Hours Requested: 48.5
Proprietary Period: 365

Abstract:
Recent research efforts to understand the evolution of galaxies and quasars are beginning to form a consistent picture. Galaxies and their supermassive black holes grow through mergers, but with decreasing characteristic mass scales over time. Much less, however, is known about the evolution of galaxies at high redshifts and the role played by energy injection from the onset of active black hole growth. Understanding these events requires investigating a statistically significant number of high-redshift quasars and crossing the L* boundary in luminosity. To construct an appropriate data set requires both relatively wide-areas (to find these rare objects) and moderate-depth imaging (to probe below L* in luminosity). Unfortunately, existing optical and MIR surveys fail to meet both of these requirements. Furthermore, both optical and MIR quasar selection are blindest at the most crucial redshifts. Here we propose to address these gaps with targeted IRAC observations of a few hundred high-redshift quasars from the Sloan Digital Sky Survey. Such a sample will enable the construction of a proper training set for the discovery of 2.5<z<5 quasars through combined optical+MIR (from IRAC channels 1 and 2) selection methods that overcome the limitations inherent to optical and MIR selection alone. By concentrating on SDSS Stripe 82, with sensitivity of i~23, we will learn how to identify high-redshift quasars in other fields over a large range in luminosity. With this knowledge, we will crack open the high-z quasar discovery space within existing IRAC legacy surveys (SWIRE, XFLS, Bootes, COSMOS). With a large sample of high-redshift quasars spanning a large range in luminosity, we can turn the quasar luminosity function and quasar clustering analysis into tools for distinguishing between different evolutionary models and feedback prescriptions. In all, we will observe 330 SDSS quasars using 307 pointings/AORs, totaling 48.5 hours of IRAC time.



Spitzer Space Telescope - General Observer Proposal #60175

Spitzer Studies of X-ray Detected Radio Hotspots

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Science Category: AGN/quasars/radio galaxies
Observing Modes: IracPostCryoMap
Hours Requested: 24.2
Proprietary Period: 365

Abstract:
We propose new observations at 3.6um of 27 hotspots in the extended lobes of radio galaxies which have also been detected in x-rays, which will be combined with archival Spitzer data on 14 additional hotspots. The hotspots arise at the interface where a jet accelerated by a black hole at the center of the galaxy plows into the local intergalactic medium. Shocks created at this interface accelerate electrons to relativistic energies, and synchrotron radiation from the electrons produces both the radio hotspot and, as the electrons diffuse away from the hotspot, the extended emission from the lobe. These hotspots play a critical role in the transport of energy from the nuclei of galaxies back into the intergalactic medium. However, our understanding of the complex and highly non-linear interactions between relativistic jets and the IGM occurring in hotspots is limited by the paucity of data in the critical region where the interplay between the ageing of electron energy distributions and the beginning of inverse Compton photons occurs. Spitzer's 3.6um band is right in the middle of this critical region, with the required sensitivity. The new observations are planned to distinguish between several models put forward for hotspots based on radio and x-ray data alone. Spitzer observations are essential for understanding these cosmic train wrecks where relativistic jets hit the IGM. No other existing facility can come close to achieving the sub-uJy sensitivity needed to detect the hotspots at 3.6um. Although our observing time request is modest, our intention to produce a catalog of multispectral data on upwards of 40 hotspots is consistent with Warm Spitzer's thrust towards comprehensive studies of important astrophysical questions.

Spitzer Space Telescope - General Observer Proposal #60173

Fossil Hunting: Intracluster Stars in Virgo

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Science Category: galaxy clusters and groups(low-z)
Observing Modes: IracPostCryoMap
Hours Requested: 100.0
Proprietary Period: 365

Abstract:
In dense clusters, galaxy interactions and mergers play a significant role in galaxy evolution. During these interactions, tidal forces can lead to the ejection of stars from their parent galaxies; these stars are a fossil record of environmentally-driven galaxy evolution. We propose to map the intracluster light (ICL) at 3.6 and 4.5um using IRAC over a square degree near the Virgo cluster core previously mapped in V-band by Mihos et al. (2005). While this study has illuminated the wealth and complexity of stellar structures in Virgo's core, the addition of IRAC data will allow us, for the first time, to: 1) accurately measure the stellar mass of the intracluster stars (ICS), constraining chemical enrichment models; 2) measure the colors of the ICS to constrain the relative ages and origins of the ICS structures; 3) identify and characterize the stellar counterparts of recently discovered gas filaments; and 4) make detailed comparisons between the atomic gas and stellar mass distribution of the cluster core, thereby providing a benchmark for cosmological simulations that trace structure formation. This program will help to elucidate our understanding of how cluster galaxies evolve, and how the ICM is affected by the removal of stars, metals, gas, and dust from in-falling galaxies.



Spitzer Space Telescope - General Observer Proposal #60099

IRAC Imaging of SPT Clusters

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Science Category: galaxy clusters and groups(high-z)
Observing Modes: IracPostCryoMap
Hours Requested: 36.6
Proprietary Period: 365

Abstract:
We propose a program to image the first sample of galaxy clusters selected at mm-wavelengths via the Sunyaev-Zeldovich Effect (SZE). We have chosen a sample of 84 robust, high-significance clusters (S/N >= 4.5) from the first 350 deg^2 of the ongoing > 1000 deg^2 South Pole Telescope (SPT) SZE survey. These clusters are selected on total mass, independently of redshift, and as such form the ideal sample for studies of massive galaxies in rich environments over a wide range of redshifts. The IRAC data will provide photometric redshifts and stellar mass estimates for both field galaxies and cluster members, allowing studies of the cluster IR luminosity and stellar mass function evolution over the last 10 Gyr in a unique, unbiased cluster sample. Finally, in concert with our ongoing, extensive multiwavelength and spectroscopic follow-up programs, the proposed data will allow empirical calibration of the relationship between SZE, X-ray, IR and dynamical measures of cluster mass, which will ultimately allow accurate constraints to be placed on the equation of state of dark energy.

Spitzer Space Telescope - General Observer Proposal #60095

The IRAC-ORELSE Survey: Galaxy Masses in Large Scale Structures at z=1

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Science Category: galaxy clusters and groups(high-z)
Observing Modes: IracPostCryoMap
Hours Requested: 59.8
Proprietary Period: 365

Abstract:
We propose an IRAC mapping campaign of 14 large scale structures at 0.7 < z < 1.3 to obtain stellar mass estimates and photometric redshifts for their constituent galaxies. As part of the Observations of Redshift Evolution in Large Scale Environments (ORELSE) Survey, these clusters represent a mix of confirmed X-ray, optically and radio selected systems. They range from multi-group mergers to superclusters with multiple clusters and groups, all with existing deep rizK_s imaging and are the subjects of a Keck-DEIMOS survey that has already yielded thousands of high-resolution spectra of constituent galaxies. The wide-area regions around high redshift clusters are are dynamic environments where galaxies are undergoing many transformative events, including mergers, tidal encounters, harassment and ram pressure stripping. By targeting known structures at an active period in their history, we can efficiently examine the physical processes responsible for the quenching and/or ignition of star formation and AGN activity, and the transformation of disk (spiral) galaxies to spheroids (ellipticals) over the last ~9 Gyr as a function of both environment and galaxy stellar mass. In comparison, field surveys such as COSMOS encounter only one such structure, while our targeted approach is an efficient means of generating a statistically significant sample. The IRAC data is essential to accurately determine photometric redshifts and estimate stellar masses for the full galaxy population in each structure.



Spitzer Space Telescope - General Observer Proposal #60112

A SURVEY OF CLUSTER-GROWTH AT EARLY EPOCHS

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Science Category: galaxy clusters and groups(high-z)
Observing Modes: IracPostCryoMap
Hours Requested: 28.9
Proprietary Period: 365

Abstract:
Forming clusters of galaxies, protoclusters, are unique laboratories for studying galaxy evolution as they contain large numbers of galaxies in the same rich environment. We propose to use Spitzer to study galaxy and cluster evolution during the formative epoch of dense structures (1.7 < z < 3) by observing a well-defined sample of 10 protocluster fields. These fields have already been observed at shorter wavelengths (Y, J, H, K) using the new HAWK-I wide-field imager on the VLT and form the first statistically significant sample of evolved protocluster galaxies ( ~ 800 protocluster galaxy candidates). We propose to obtain 3.6 and 4.5 micron data on the 10 fields in order to: (i) distinguish between dusty starbursts and passively evolving galaxies; and (ii) measure the masses of the protocluster galaxies. The Spitzer data will facilitate population studies of high density environments, enabling us to create the first mass-selected samples of galaxies in protoclusters at 1.7 < z < 3, and select H-alpha emitting starburst galaxies for spectroscopic follow-up.

Spitzer Space Telescope - General Observer Proposal #60142

Infrared outburst in Arp 299

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Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IracPostCryoMap
Hours Requested: 0.4
Proprietary Period: 365

Abstract:
Arp 299 is one of the nearest examples of a luminous infrared galaxy. We discovered a strong infrared outburst in Arp 299 at near-infrared wavelengths which we have been monitoring now for four years. The outburst is apparent at infrared wavelengths but not in the optical indicating emission from warm dust and a high extinction. This source could originate from an IR 'dust echo' resulting either from a very energetic and highly obscured SN or an outburst of a highly obscured active galactic nucleus. To study the origin of this outburst we propose short IRAC observations.



Spitzer Space Telescope - General Observer Proposal #60101

Light Echoes of Historical Galactic Supernovae

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Science Category: ISM
Observing Modes: IracPostCryoMap
Hours Requested: 26.6
Proprietary Period: 365

Abstract:
Spitzer's serendipitous discovery of light echoes from the supernovae (SN) that gave birth to the Cas A supernova remnant (SNR) shows that we have to opportunity to re-observe historical Galactic supernovae. Optical spectra of these echoes have shown that the Cas A SN was of Type IIb. Similarly, Tycho's SN has been spectroscopically established to be of Type Ia. The Cas A light echoes are the only ones seen by Spitzer to date. However, this is because existing observations of other young galactic SNRs have only included a single epoch of observations (insufficient to reveal the highly transitory echoes), and have only covered small fields in the immediate vicinity of the SNRs. We proposed to obtain wide field (>0.5 degree) observations of the 7 youngest Galactic SNe, having ages up to ~1000 yr. Where available, prior epoch observations will allow definitive identification of light echoes. If the Cas A echoes are representative, we can also identify echo candidates via their distinctive 4.5/3.6 micron colors. Variations (or lack thereof) in these colors as a function of SN age and SN type, will allow us to place constraints on the emission mechanism of the echoes (absorption and re-radiation vs. scattering). Low extinction at 3.6 and 4.5 microns, means that Spitzer can located echoes of distant SNe which may be too highly attenuated to observe at shorter wavelengths.

Spitzer Space Telescope - General Observer Proposal #60060

A Wide-Field Survey for Low Mass Star Formation around the Galactic Massive Young Cluster NGC 3603

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Science Category: star formation
Observing Modes: IracPostCryoMap
Hours Requested: 3.8
Proprietary Period: 365

Abstract:
NGC 3603 is one of the most massive (~10,000 solar masses) and compact (5~pc) young star clusters known in the Milky Way. It is therefore a candidate young globular cluster, with properties similar to massive young clusters found in other galaxies such as the LMC, M51 and the Antenna. Due to its proxmity and low extinction, NGC 3603 is one of the few massive clusters where it is possible to detect the low mass stars that dominate the total mass of the cluster. NGC 3603 lies in the center of a 40 pc diameter, 100,000 solar mass molecular cloud complex; little is known about the stars forming in this complex. We propose the first systematic survey of this complex using deep 3.6 and 4.5 micron Spitzer imaging of a 59 by 57 pc region centered on NGC 3603. By combining this data with scheduled VLT JHK imaging of the same field, we can detect and identify low to intermediate mass stars with disks and protostars in the cloud complex. Our goal is to probe the relationship between spatially extended OB associations and compact clusters of OB stars. Our method is to compare the spatial distribution of intermediate to low mass stars in the extended NGC 3603 complex to that found in OB associations like Orion. Specifically, is NGC 3603 part of a large, extended complex containing both clustered and distributed star formation, and consequently similar to nearby associations? Or did NGC 3603 result from a distinct, compact mode of star formation? These observations will give us unique insight into the process of massive star cluster formation in other galaxies and how this process may differ from star formation near the Sun.



Spitzer Space Telescope - General Observer Proposal #60181

Small Clusters Forming in Isolation? CB 34 and CB 58

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Science Category: star formation
Observing Modes: IracPostCryoMap
Hours Requested: 1.8
Proprietary Period: 365

Abstract:
In our previous survey of Bok globules in search of small clusters forming within these isolated regions, we found evidence in the MIPS data for two small clusters forming near our original targets. We propose Spitzer IRAC observations of these small extensions of our current IRAC maps in CB 34 and CB 58 so that we will have a complete census of the young stellar objects (YSOs) in these regions. CB 34 appears to be a cluster forming in isolation, whereas CB 58 appears to have the morphology of a bright-rimmed cloud. With these observations, and combined with existing near-infrared and radio data, we will measure the star formation efficiency in these Bok globules. In addition, we will study the role environment plays in star formation by comparing the properties of YSOs in Bok globules, which are relatively isolated from outside influences, with bright-rimmed clouds, which are examples of triggered star formation.

Spitzer Space Telescope - General Observer Proposal #60078

Triggered Star Formation and the Power within PacMan

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Science Category: star formation
Observing Modes: IracPostCryoMap
Hours Requested: 6.1
Proprietary Period: 365

Abstract:
NGC 281 (a.k.a. the Pac Man Nebula) is a complex region of star formation. At a distance of about 3 kpc is lies a remarkable 300 pc above the galactic plane. Apparently triggered by a supernova that occurred 6 Myr ago, it includes at least 3 separate but related sites of star formation within 4 pc. The oldest regions includes a trapezium-like set of several 3.5 Myr O stars while the youngest regions are still active. In addition to hundreds of young stars, our recent Chandra observation, revealed copious plasma surrounding the O stars and impacting on at least one of the active regions. We will determine whether the clusters are part of a single, continuous cluster, or whether they are separate clusters created by distinct episodes of star formation - and distinguish between predictions made by 'collect & collapse' or radiation driven implosion models (RDI). The face-on aspect of the region allows us to study the diffuse plasma in the region to understand the role of X-ray ionization along the HII region/molecular cloud interface. We propose to map the region using IRAC in order to study: 1.) The mechanism of the triggered star formation within the embedded clouds. 2.) The relationship between hot plasma and molecular clouds and to look for dust in and around the hot plasma 3.) The disk frequency of massive stars (1-2 Msun) in molecular cloud, in cluster surrounding OB stars, and in the hot plasma.



Spitzer Space Telescope - General Observer Proposal #60167

Disk tomography and dynamics: a time-dependent study of known mid-infrared variable young stellar objects

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Science Category: young stellar objects
Observing Modes: IracPostCryoMap
Hours Requested: 49.3
Proprietary Period: 365

Abstract:
Most of our knowledge on young stars comes from snapshot observations: spectra and images taken at a single epoch, or at different epochs at different wavelengths. It is, however, known that many of the systems are variable. Variability at optical and near-infrared wavelength is mostly related to the central star itself. Mid-infrared flux changes, on the other hand, are in most cases due to varying emission of the circumstellar material, either via varying accretion rate (and thus changing thermal emission), or varying extinction along the line-of-sight (shadowing effects). If the illuminated disk area varies with time, measuring the variable integrated flux offers a tomographic analysis. Monitoring and interpreting variability provide a powerful 'extra dimension' of information on the structure of the circumstellar material. The Spitzer Warm Mission is a unique opportunity for the systematic establishment of mid-infrared variability studies of young stars. Following an extensive preparatory work, we compiled a list of young stellar objects with variable mid-infrared brightness. We propose to conduct a multi-epoch survey of these carefully selected pre-main sequence stars with Spitzer. We plan to complement the Spitzer observations with simultaneous optical and near-infrared photometry from ground-based telescopes. Our aim is to document the mid-infrared brightness evolution of our targets, examine the possible reasons of the observed variability, model disk structure and dynamics for different scenarios and confront the data with model predictions.

Spitzer Space Telescope - General Observer Proposal #60160

An Exploration of Unique Mid-Infrared Variability around Transition Disks and Class I stars in IC 348

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Science Category: young stellar objects
Observing Modes: IracPostCryoMap
Hours Requested: 21.5
Proprietary Period: 365

Abstract:
We propose to obtain repeated 3.6 and 4.5 micron observations of IC 348 focusing on young stellar objects that show evidence of unique and unusual mid-infrared variability. Previous Spitzer observations have found variations in the mid-infrared flux in as little as a day along with a strong wavelength dependence. We focus on a handful of T Tauri stars that exhibit spectral energy distributions similar to transition disks and two class I stars that show the largest 24 micron variability of any young stellar object in the cluster. In the T Tauri disks the variability may be related to a change in the scale height of the inner edge of this disk. Repeated observations covering a range of timescales from hours to weeks will help to constrain the physical mechanism leading to this variable scale height. For the class I stars, our proposed observations will help to constrain the details of the envelope/disk structure and variable accretion. These data will provide an essential tool for understanding stellar mass build up, accretion and planet formation.



Spitzer Space Telescope - General Observer Proposal #60109

Measuring YSO inner accretion disk sizes, structure and dynamics with staring mode observations of 14 YSOs in Rho Ophiuchus

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Science Category: young stellar objects
Observing Modes: IracPostCryoMap
Hours Requested: 24.0
Proprietary Period: 365

Abstract:
Variability is almost a defining characteristic of young stellar objects (YSOs). We propose a program to monitor YSOs with IRAC channel 2 in staring mode for 3 sets of 8 hours. This proposal is complementary to our Exploration Science Spitzer program YSOVAR, which measures variability on timescales greater than 4 hours. With the proposed observations, we will probe disk accretion dynamics on timescales from ~1 minute to 4 hours. Furthermore, we will carry out a novel application of the AGN reverberation mapping technique to YSOs to measure inner disk edge sizes. Combined with ground-based contemporaneous near-IR monitoring, we will be able to measure light travel time delays as short as 25 seconds from the reprocessed dust emission (~0.05 AU). We have constructed a model that confirms the feasibility of measuring these short time-lags, and it requires high-precision mid-infrared photometry that only Spitzer can provide. We have selected a field of 8 nearby, bright Class I and II YSOs in Rho Ophiuchus that contains known near-infrared variables to carry out this pilot program.

Spitzer Space Telescope - General Observer Proposal #60014

Young Stellar Object Variability (YSOVAR): Mid Infrared Clues to Accretion Disk Physics and Protostar Rotational Evolution

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Science Category: young stellar objects
Observing Modes: IracPostCryoMap
Hours Requested: 550.0
Proprietary Period: 60

Abstract:
Spitzer/IRAC in the warm mission is the only facility now existing or planned capable of carrying out an extensive, accurate time series photometric monitoring survey of star-forming regions in the thermal infrared. The demonstrated sensitivity and stability of IRAC allows measurement of the relative fluxes of YSO's down to the substellar mass limit to 1-2% accuracy in star-forming regions out to >500 pc. We propose a time series monitoring exploration science survey of the Orion Nebula Cluster and 11 very young, populous embedded star-forming cores which will provide >= 80 epochs of data for > 1500 YSO's. We will complement these observations with contemporaneous optical and near-IR monitoring data in order to allow comparison of the phase, amplitude and light-curve shape as a function of wavelength. These data will allow us to: (a) provide otherwise unobtainable constraints on the structure of the inner disks in Class I and II YSOs - and hence, perhaps, provide clues to the



formation and migration of planets at young ages; (b) measure the short and long-term stability of hot spots on the surfaces of YSO's of all evolutionary stages; and (c) determine rotational periods for the largest sample to date of Class I YSO's and hence obtain the best measure of the initial angular momentum distribution of young stars.

Spitzer Space Telescope - General Observer Proposal #60063

Exoplanet HAT-P-11b Secondary Transit Observations

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 48.2
Proprietary Period: 365

Abstract:
We propose to conduct secondary eclipse observations of exoplanet HAT-P-11b, recently discovered by proposal Co-Investigator G. Bakos and his colleagues. HAT-P-11b is the smallest transiting extrasolar planet yet found and one of only two known exo-Neptunes. We will observe the system at 3.6 microns for a period of 22 hours centered on the anticipated secondary eclipse time, to detect the eclipse and determine its phase. Once the secondary eclipse is located, we will make a more focused series of observations in both the 3.6 and 4.5 micron bands to fully characterize it. HAT-P-11b has a period of 4.8878 days, radius of 0.422 RJ, mass of 0.081 MJ and semi-major axis 0.053 AU. Measurements of the secondary eclipse will clarify two key issues; 1) the planetary brightness temperature and the nature of its atmosphere, and 2) the eccentricity of its orbit, with implications for its dynamical evolution. A precise determination of the orbit phase for the secondary eclipse will also be of great utility for Kepler observations of this system at visible wavelengths.



Spitzer Space Telescope - General Observer Proposal #60161

Cool, spatially resolved substellar and exoplanetary analogues at white dwarfs

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 25.1
Proprietary Period: 365

Abstract:
We propose to obtain second epoch IRAC 4.5 micron images of 87 nearby white dwarfs that were originally observed at the same wavelength during the first two cycles of the Spitzer mission. By combining the data at these two epochs, we will search for spatially resolved T and sub-T-type brown dwarf, and massive planetary companions via common proper motions with their primaries. These observations will comprise the deepest survey to date for wide substellar and planetary-mass companions to white dwarfs in the solar neighborhood. Owing to the known distance and age of each white dwarf, any companions identified in this program would provide a benchmark for examining evolutionary models at ages from a few 100 Myr to several Gyr. This survey will also provide the best statistical limits yet on the frequency of such objects at white dwarfs and their intermediate mass, main-sequence progenitors.

Spitzer Space Telescope - General Observer Proposal #60028

Confirmation and Characterization of Kepler Mission Exoplanets: The Era of Rock and Ice Exoplanets

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 800.0
Proprietary Period: 90

Abstract:
In the past 4 years, the combination of ground-based transit surveys and the remarkable stability of the Spitzer Space Telescope permitted the direct investigation of the atmospheres of one specific class of exoplanet, namely the Hot Jupiters. The power of the NASA Kepler Mission will be to discover dozens of transiting exoplanets that are not detectable from the ground either due to the shallow transit depth or the low transit frequency resulting from their longer orbital periods. Kepler will find large numbers of transiting hot Neptunes and hot SuperEarth exoplanets, as well as cooler Jupiters, each of which are nonetheless amenable to direct study of their infrared emission. We propose to use Spitzer to observe Kepler-detected exoplanets and candidates to pursue two goals. First, we will measure the two-color planetary emission for 20 representative members of these previously inaccessible cexoplanets. Such observations will permit the first opportunity to directly test theoretical models of exoplanetary atmospheres of varying compositions (notably SuperEarths and Neptunes) and under differing levels of irradiation (cooler Jovian companions). The same data will permit an estimate of the orbital eccentricities, thus providing a test of models of the orbital migration, and tidal dissipation for these various types of exoplanets. Second, we will use Spitzer to follow up Kepler-identified candidate terrestrial exoplanets to prove that these signals are indeed planetary in origin. By gathering single color time series spanning times of primary transit, we will exclude a significant source of astrophysical false positives (resulting from blends of triple stars systems containing an eclipsing binary) that will precisely mimic an exoplanetary signature in the Kepler data. These infrared data will provide a crucial step in confirming the planetary nature of many of the most exciting candidates, namely the planets with the smallest radii that are likely rocky in composition.



Spitzer Space Telescope - General Observer Proposal #60113

A Search for Circumstellar Dust at SDSS White Dwarfs with K-Band Excess

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 6.7
Proprietary Period: 365

Abstract:
We propose IRAC 3.6 and 4.5 micron observations of white dwarfs observed to have a K-band excess via cross-correlation of the the Sloan Digital Sky Survey (SDSS) and the UKIRT Infrared Deep Sky Survey (UKIDSS). We have searched tens of thousands of sources in SDSS DR7 with spectra (by eye) and/or photometry and identified a few thousand SDSS white dwarfs with good YJHK photometry in UKIDSS. Of those sources, we select the best seven candidates with a likely K-band excess to search with Spitzer / IRAC for confirmation of warm circumstellar dust. Our selection criteria should be both completely unbiased and highly efficient relative to previous white dwarf dust disk searches. There is now strong evidence that the closely orbiting dust disks at white dwarfs are caused by the tidal disruption of a minor planet or planets. In addition to producing an infrared excess, the debris also pollutes the otherwise pristine white dwarf atmosphere with metals, via accretion. Any confirmed dust disks will almost certainly have contaminated their white dwarf hosts, but metal absorption features cannot typically be seen in the relatively low S/N and low resolution SDSS spectra. However, ground- and space-based ultraviolet and optical spectroscopy of the heavy element abundances (at high resolution and superior S/N) will yield the bulk composition of the terrestrial, polluting material. Our targets represent high probability of dust disk detection and, if confirmed, will substantially increase the number of exoplanetary debris disks for which a bulk chemical composition can be obtained.

Spitzer Space Telescope - General Observer Proposal #60119

Completing the Census of Disrupted Minor Planets at White Dwarfs: Photospheric Pollution by Single or Multiple Asteroids?

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 3.7
Proprietary Period: 365

Abstract:
We propose IRAC photometry for a sample of 11 highly metal-enriched white dwarfs, to confirm or rule out infrared excess due to warm circumstellar dust. Our ongoing Spitzer work has been highly successful in the identification of white dwarfs that are, simultaneously, externally polluted by metals and have closely orbiting circumstellar dust. Both the orbiting material and the photospheric heavy element abundances are refractory-rich and volatile-poor, implying these stars are polluted by rocky material. In this way we continue to build a target list on which to perform spectroscopy of extrasolar rocky planetesimals, via their heavy element signatures in the otherwise pristine photospheres of white dwarfs. No other currently available technique can observe the bulk composition of extrasolar, terrestrial, planetary material -- this is the singular, enormous advantage offered by metal-rich white dwarfs. Our model invokes the tidal destruction of a single, large asteroid to produce circumstellar dust, while multiple, smaller asteroids are invoked to explain stars that are dust-free. In the latter case, orbiting dust is readily destroyed via collisions and sputtering as additional asteroids enter a pre-existing, closely orbiting disk at slightly different inclinations, resulting in a gaseous disk. In both cases, the white dwarf accretes, and becomes polluted by, material which is rich in heavy elements. Therefore, identification of warm circumstellar dust implies pollution by a single body, whose heavy element abundances should reflect an idiosyncratic pattern of an extrasolar analog to a large asteroid like Ceres. On the other hand, a lack of orbiting dust implies the metal abundance pattern reflects pollution by an ensemble of smaller extrasolar asteroids, and closer to an average chemical composition. Discriminating between these two cases is critical to the interpretation of optical and ultraviolet spectroscopy of the photospheric heavy elements seen in polluted white dwarfs.



Spitzer Space Telescope - Directors Discretionary Time Proposal #60027

Detecting the Transits of Nearby Super-Earths

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Science Category: extrasolar planets
Hours Requested: 100.0

Abstract:
We have an amazing opportunity to change the field of exoplanet characterization by finding Super-Earths transiting bright nearby stars. Our HARPS radial-velocity survey has detected more than 50 low-mass planets in the solar vicinity, most of them being short period Super-Earths having a large transit probability. We propose an Exploration Science Program of 500 hours to detect the few of them that transit their host star. These detections will bring exoplanetology into the realm of terrestrial planets. The expected harvest of the proposed project is the detection of 1 - 2 transiting Super-Earths and 1 transiting hot Neptune. Future ambitious transit surveys like Kepler should detect much more low-mass planets, but the faintness of the target stars means thorough characterization of detected Kepler planets will not be possible with existing or near-future instruments like JWST. On the contrary, the few planets that will be detected by the proposed project all will be exquisite targets for high S/N follow-up studies. In particular, they will enable the first studies of the atmospheric properties and habitability of terrestrial extrasolar planets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #60003

The Spitzer Exoplanetary Atmosphere Survey

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Science Category: extrasolar planets
Target of Opportunity: Yes
Hours Requested: 200.0

Abstract:
We propose a Target of Opportunity (ToO) program to observe photometric eclipses and transits of extrasolar planets. Spitzer eclipses are the most fundamental (and in many cases the only) direct exoplanetary measurements possible with current instrumentation; transits measure the radius and eclipses the intrinsic fluxes from these worlds. We will populate a figure of predicted equilibrium vs. observed brightness temperatures, which is starting to show patterns indicating different classes of atmospheric behavior. The observations will constrain models of composition, chemistry, and atmospheric dynamics on each planet. The events will also inform follow-on work with other telescopes for the brightest targets. Based on discovery statistics, 25-35 new, observable, transiting planets will be announced in 2009, and somewhat more in 2010. Also, a number of known planets with good predicted signal have not yet been observed. We will publish digital lightcurves with journal articles and submit them for archiving. No comparable opportunity to observe exoplanets will be available until JWST.



Spitzer Space Telescope - General Observer Proposal #60021

Dynamic Studies of Exoplanet Atmospheres: From Global Properties to Local Physics

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 1138.0
Proprietary Period: 0

Abstract:
Spitzer's two-year warm mission represents a unique opportunity to build on its already-substantial legacy in the area of exoplanetary science with a comprehensive set of observations that would directly address fundamental questions about the physical processes that shape exoplanet atmospheres. In our proposal we outline an exciting two-pronged approach that would combine a survey of the secondary eclipses for all of the known transiting planets not already observed during the cryogenic mission with a set of phase curve observations targeting five of the most interesting objects. The first part of our study would more than double the number of systems with secondary eclipse observations and provide the statistical leverage needed to characterize the nature of the high-altitude absorber responsible for the presence of temperature inversions in the atmospheres of HD 209458b, TrES-2, TrES-4, and XO-1b. Secondary eclipse observations alone are not enough, however, as we expect the properties of these tidally-locked planets may vary substantially between the permanent day and night sides. Phase curve observations of select systems at several wavelengths allow us to map out longitudinal variations in the pressure-temperature profiles, chemistry, clouds, and circulation patterns of these highly-irradiated atmospheres, and such spatially resolved information will be absolutely critical in interpreting the results of the broader, low-resolution survey. Comparisons between the two benchmark systems HD 209458b and HD 189733b as well as a carefully-selected set of additional planets will allow us to investigate the importance of irradiation, rotation rate, surface gravity, eccentricity, and stellar metallicity in determining the pressure-temperature structure and dynamic meteorology of these atmospheres. We are requesting a total of 1138 hours for these observations.

Spitzer Space Telescope - General Observer Proposal #60102

Two for the Show: Observing the Periastron Passages of HD 80606 b

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 84.3
Proprietary Period: 365

Abstract:
In Cycle 4, we observed a periastron passage of the eccentric giant HD 80606 b in Spitzer's 8-micron IRAC band, obtaining evidence of rapid heating during periastron, as well as discovering that the planet undergoes secondary eclipse several hours prior to periastron. Here, we are proposing to follow up on this success with observations of two near-term periastron passages in the 4.5 micron band. These observations will yield a number of concrete benefits: 1.) Measurement of the baseline flux of the planet at 4.5 microns will improve the characterization of the pre-periastron luminosity of the planet, and will thereby clarify the role of tidal dissipation in heating the planet, which will in turn yield insight into the planetary structure. 2.) Measurements of the secondary transit depth at 4.5 microns will give insight into the bolometric temperature of the planet, providing important constraints on all hydrodynamical models of exoplanet atmospheres. 3.) Measurement of the heating rate at 4.5 microns prior to periastron will improve knowledge of the infrared radiative timescale, which forms an essential constraint on competing exoplanetary general circulation models under development. If one has heating rates at both 4.5 microns and 8 microns, then the bulk energetics of the planet's infrared photosphere are clearer than if one relies on a brightness temperature derived from a single frequency. 4.) The 8-micron observations did not extend long enough after the periastron passage to determine the cooling rate as the planet recedes from its primary. Our proposed observations will run well past periastron, which will allow a more accurate determination of the post-periastron cooling rate, again providing vital constraints on both hydrodynamical and radiative models of strongly irradiated exoplanetary atmospheres. To achieve these goals, we are requesting 40 hours of observation time for each of the two periastron passages that will occur in Cycle 6 -- a total of 80 hours of observation time.



Spitzer Space Telescope - General Observer Proposal #60058

Dynamic atmosphere of the eccentric and massive planet XO-3b

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 131.3
Proprietary Period: 0

Abstract:
We propose to observe the extended duration (63.0 hours) phase light curves spanning the transit and secondary eclipse of the exoplanet XO-3b, which has a period of 3.19 days, in the 3.6 and 4.5 micron IRAC bands to study the presence of a thermal inversion in its stratosphere and determine the phase variability of the planetary emission temperature. Full phase 3.6 and 4.5 micron photometry will allow us to constrain the longitudinal variation of the XO-3b emission, determine the day-night side heat circulation as well as constrain the presence of any hot-spots on the surface. XO-3b is an unique planet with a high mass Mp = 12.5 MJup, which is close to the deuterium burning limit and so far has the highest observed surface gravity, g = 209 m.s^-2 amongst the known transiting planets. Its orbit has eccentricity e = 0.287, which causes stellar irradiance to vary three-fold over the entire orbit. Unique to XO-3b, the planet revolves around the star on an almost polar orbit with a 70 +/- 15 deg inclination angle relative to the stellar equatorial plane . Of the 11 transiting planets with measured Rossitter-McLaughlin effect, XO-3b is the only one with a nearly polar orbit, thus XO-3b represents a new orbital mode of transiting Hot Jupiters, which in principle would allow us to constrain the latitudinal distribution of the thermal emission from the planet, in addition to the longitudinal thermal distribution. This proposal is a follow-up to the approved Cycle-5 Cold Spitzer DDT program OX3B 'Thermal Inversion in the atmosphere of XO-3b', which investigates the secondary eclipse of XO-3b in all 4 IRAC channels.

Spitzer Space Telescope - General Observer Proposal #60134

WASP-17 - testing the paradigm of pM/pL class planets

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 17.4
Proprietary Period: 365

Abstract:
The structure, formation and fate of hot Jupiter exoplanets is governed by the properties of their atmospheres. There is an urgent need for for strong observational constraints to guide the development of model atmospheres for hot Jupiters. WASP-17b is a newly discovered transiting hot Jupiter exoplanet. It has the lowest density of any transiting hot Jupiter discovered to-date. The host star, WASP-17, is a bright (V=11.6) F6V star. This combination of factors make WASP-17 a key object for testing the current paradigm in which hot pM class planets have stratospheres and cooler pL class planets do not. We will use Spitzer to observe the secondary eclipse of the planet by its host star at 3.6um and 4.5um, and use these data to measure the brightness temperature at these wavelenghs. In the current paradigm, this pM class planet should show evidence of a stratosphere from the ratio of the brightness temperatures at these wavelengths. We will also use transmission spectroscopy to determine independently whether WASP-17b has a stratoshere. VLT time to obtain the required spectroscopy has already been approved. WASP-17 is currently the only pM class planet apart from HD209458 for which the results from the two methods can be compared. The Spitzer data that we will obtain for WASP-17 are essential for us to fully understand exploit the Spitzer observations of exoplanets that will be obtained in the warm mission.



Spitzer Space Telescope - General Observer Proposal #60185

Lightcurves of two newly discovered ultra-short period planets

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Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Requested: 60.0
Proprietary Period: 365

Abstract:
The structure, formation and fate of hot Jupiter exoplanets is governed by the properties of their atmospheres. There is an urgent need for for strong observational constraints to guide the development of model atmospheres for hot Jupiters. One of the most powerful techniques for probing hot Jupiter atmospheres is to observe the small variation in infrared flux through the orbital cycle for transiting hot Jupiters. These observations can be converted into a map of the temperature distribution around the planet. This gives us a direct measurement of the way heat is redistributed through the planet's atmosphere. The processes that redistribute heat from the day-side to the night-side in these tidally locked planets are very poorly understood. This limits our ability to interpret observations of hot Jupiters obtained with Spitzer and other instruments. Phase variations are small so they have only been succesfully observed in a handful of hot Jupiter systems. There are, as yet, no detections of the phase variation in any transiting hot-Jupiters with atmospheres hot enough to have a stratosphere, and only one (HD189733) for a cooler transiting hot Jupiter. We will observe the lightcurves of WASP-18 and WASP-19, to newly discovered ultra-short period planets (P<1day). These are key objects for understanding heat redistribution in hot Jupiters because the irradiation of their day-side is so extreme.

Spitzer Space Telescope - General Observer Proposal #60169

Search for Pulsation in Young Brown Dwarfs

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Science Category: brown dwarfs/very low mass stars
Observing Modes: IracPostCryoMap
Hours Requested: 24.0
Proprietary Period: 365

Abstract:
Brown dwarfs are a ubiquitous yet poorly understood product of the processes that take place in star formation regions. To date, observational methods to determine important properties such as mass and age are lacking. But better understanding of the physical characteristics of young brown dwarfs and very low mass stars is now within reach through the signature of variable lightcurves. In particular, pulsation in these objects is a newly suggested phenomenon that offers unprecedented opportunities to probe their interiors and evolution. We propose to use Spitzer IRAC to improve upon ground-based studies which suggest low-amplitude, short-period variability indicative of pulsation just below the statistical detection threshold. We will acquire precise time-series photometry on a sample of confirmed brown dwarfs in the young Sigma Orionis cluster. With estimated masses and ages appropriate to the deuterium-burning stage, these objects are some of the most promising candidates in a potential new class of pulsators. We aim to fully characterize light-curve periodicities down to millimagnitude amplitudes, and ultimately use the results to provide fundamental constraints on the interiors and properties of brown dwarfs.



Spitzer Space Telescope - General Observer Proposal #60093

3 - 5 micron Photometry of 500 - 800 K Brown Dwarfs

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Science Category: brown dwarfs/very low mass stars
Observing Modes: IracPostCryoMap
Hours Requested: 9.1
Proprietary Period: 365

Abstract:
We request 9.1hrs to obtain IRAC photometry of 11 cold brown dwarfs. The observations will complete the dataset of near-infrared spectroscopy and 1-5um photometry, for known brown dwarfs with spectral types >T7, and temperatures of 500K to 800K. These rare very late- type T dwarfs are the coolest objects known outside of the solar system. For these the [3.6] band samples a low-flux region of strong CH4 absorption, and the [4.5] band a bright region subject to absorption by dredged-up CO. The [4.5] flux becomes increasingly dominant at low temperatures, and is the best temperature indicator for the latest T dwarfs, for which the near- infrared features are saturated. Combining accurate IRAC photometry with our near-infrared data, and models, will allow us to constrain temperature, metallicity and gravity, as well as vertical mixing in the atmospheres of our targets. Now that objects as cool as ~500K are being found it is vital that we understand their behaviour in the mid-infrared, especially in the WISE era, when the red [3.6]-[4.5] color will be used to find even more extreme objects.

Spitzer Space Telescope - General Observer Proposal #60046

A Survey for Wide Substellar Companions in the Solar Neighborhood

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Science Category: brown dwarfs/very low mass stars
Observing Modes: IracPostCryoMap
Hours Requested: 28.8
Proprietary Period: 365

Abstract:
We propose to obtain IRAC images of 328 stars, brown dwarfs, and white dwarfs in the solar neighborhood that have been observed previously with IRAC. By combining the data at these two epochs, we will search for wide (>100 AU) substellar companions through their common proper motions with the primaries. The detection limits will reach up to 100 times fainter than the faintest known T dwarfs. These observations will comprise the deepest survey for wide companions to nearby stars that is possible with any current or planned telescope, providing the best available opportunity for finding brown dwarfs cooler than known T dwarfs, such as the as-of-yet-undiscovered Y dwarfs.



Spitzer Space Telescope - General Observer Proposal #60122

A Survey for Dust in Type IIn Supernovae

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Science Category: evolved stars/pn/sne
Observing Modes: IracPostCryoMap
Hours Requested: 22.4
Proprietary Period: 365

Abstract:
We propose to carry out a Spitzer/IRAC mid-infrared survey for thermal dust emission in all observable Type IIn supernovae from the past 10 years. The source of the large amounts of dust observed in high redshift galaxies has remained uncertain for nearly 40 years. Despite the success of models in producing dust within supernova explosions, only a handful of supernovae show direct observational evidence for dust condensation, and these examples all yield 2-3 orders of magnitude less dust than predicted by the models. Recent observations suggest Type IIn supernovae may condense more dust than typical core-collapse events. Due to the small number of Type IIn events (2-3% of all core-collapse supernovae), there exist too little data to draw any unbiased conclusions concerning the nature of dust production in this particular subclass. The few dust forming Type IIn supernovae, however, show late-time infrared emission sometimes more than five or six years following their initial detection, making remnant archeology possible. While previous Spitzer/IRAC surveys have searched for dust in supernovae, none have targeted these Type IIn events. A Spitzer/IRAC follow-up survey of all observable Type IIn supernovae from the past ten years will determine the extent to which this subclass produces dust. Ground-based observations are insufficient. Spitzer/IRAC provides the necessary sensitivity at wavelengths spanning the peak of the blackbody emission from the warmest grains, as well as the tail-end emission from colder dust. With only 5 minutes of integration in both 3.6 and 4.5 micron bands, this survey is sensitive to dust in almost all of our targets given our flux estimates. In only 22.4 hours, we can obtain follow-up photometry in both bands for all positions of observable Type IIn supernovae discovered in the past ten years.

Spitzer Space Telescope - General Observer Proposal #60020

GLIMPSE360: Completing the Spitzer Galactic Plane Survey

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Science Category: galactic structure
Observing Modes: IracPostCryoMap
Hours Requested: 1980.3
Proprietary Period: 0



Abstract:
We propose to map the remaining 187 degrees of the Galactic Plane that have not been observed with the Spitzer Space Telescope. The survey will cover longitude l=65-265 degrees excluding l ~102-109 and l~76-82. The latitude range will be 3.1 degrees, wider than the previous GLIMPSE surveys (2 degrees) because the disk flares more in the Outer Galaxy. The latitude center will follow the Galactic warp. Three visits on each sky position with 0.6&12s HDR frames will provide a high dynamic range of sensitivity that exceeds both GLIMPSE and the planned WISE mission surveys at both ends. This will allow us to determine the edge of the Galactic stellar disk, study low and high mass star formation in the nearby Perseus arm as well as in the Far Outer Galaxy, and study evolved stars throughout the Galaxy. The combination of GLIMPSE360 and the previous GLIMPSE (

Spitzer Space Telescope - General Observer Proposal #60107

Investigating the Nature of Dust Disks in Weakly-Magnetic Cataclysmic Variables

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Co-Investigators:
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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 20.4
Proprietary Period: 365

Abstract:
We propose to obtain 4.5 micron light curves and a single 3.6 micron measurement of four intermediate polars, a class of weakly-magnetic cataclysmic variables (CVs), in order to investigate the nature of dust in CVs. This proposal is motivated by results from our Cycle 2 observations, in which we discovered the presence of circumbinary dust disks in highly-magnetic CVs, and our Cycle 4 observations, in which 4.5 and 8 micron light curves of the non-magnetic CV, WZ Sge, revealed the presence of previously undetected dust associated with the accretion disk within the binary. This dichotomy in dust properties may be the result of evolutionary differences between highly-magnetic and non-magnetic CVs, or the different accretion processes occurring within the systems. Intermediate polars present a blend of non-magnetic and highly-magnetic CV properties, and therefore, Spitzer time-series observations of these systems will help to answer many of the questions that arose after our Cycle 2 and Cycle 4 observations, and will also answer outstanding questions about intermediate polars, such as if they are evolutionarily linked to highly-magnetic systems and how the cool component of the accretion disk is affected by the truncation of the hot inner component of the disk. The proposed observations will also have great relevance for our understanding of the physics and structure of accretion disks in general, those in binary systems as well as in active galaxies.



Spitzer Space Telescope - General Observer Proposal #60130

Rapid variability of jets in X-ray binaries: a new tool.

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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 8.1
Proprietary Period: 365

Abstract:
We propose to observe Cyg X-1, an accreting black hole, and Sco X-1, an accreting neutron star, with a 2-hour long uninterrupted exposure each with IRAC in high time resolution modes. Their rapidly variable IR components are likely to come from relativistic jets, and these data will provide important insights into how these jets are powered by the systems' accretion disks. While jets appear as a byproduct of the accretion process, there is as yet no standard model for their underlying physics. Several key issues are be solved, including the geometry of jets, their energetic power and their coupling with the disk. Multwavelength fast variability is an exciting new tool, which will provide new informations. For the first time, we will study the fast jet variability in great detail, opening a new promising window on the Physics of accretion. These explorative observations will provide a measure of the size of the emitting region, thus constraining the jet geometry. By studying the correlated variability in mid-IR and X-rays, we will put important constraints to the jet-disk connection. Finally, by comparing these results between the two sources, we will cast light on the jet energetic budget, which is thought to be different in black holes and in neutron stars.

Spitzer Space Telescope - General Observer Proposal #60086

Characterizing the Periodic Infrared Brightening Events of GX17+2: A Precessing Synchrotron Jet?

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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 3.6
Proprietary Period: 365

Abstract:
GX17+2 is a low mass X-ray binary, and one of the brightest X-ray sources in the sky. It is also a 'Z Source' so named by the path this small family of objects traces out in the X-ray color-color diagram. This Z-pattern is believed to occur due to the changing rate of accretion, which is normally quite close to the Eddington limit for a neutron star. GX17+2 seems to be a normal member of this class of object, with stochastic X-ray and radio variations. The one exception to this is that the infrared counterpart shows four magnitude variations in the K-band. Even more peculiar is that these 'outbursts' are periodic and recur every 3.01 days! Unfortunately, GX17+2 is highly reddened (Av > 19) and is not detectable at other ground-based wavelengths. Thus, we cannot conclusively identify the nature of these outbursts, but our radio observations show that it is radio loud during these infrared events. This suggests that we are seeing a precessing synchrotron jet. While there is evidence for precessing jets in other X-ray binaries, such a short precession period is unprecedented. We propose to obtain simultaneous K-band and IRAC 3.6 and 4.5 micron observations of GX17+2 during two IR bright phases to allow us to deconvolve the reddening and spectrum of the source to allow us to confirm whether these outbursts are from optically thin synchrotron emission. Such jets are expected to be highly variable, and the short exposure times offered by Spitzer will allow us to characterize this variability. The proposed program requires 3.6 hr.



Spitzer Space Telescope - General Observer Proposal #60056

The mass and radius of a low mass white dwarf

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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 23.2
Proprietary Period: 365

Abstract:
The mass-radius relation and cooling timescale for low-mass white dwarfs depends on their composition, particularly the amount of hydrogen remaining on their surface. There are currently no strong observational constraints on this parameter. This severely limits our ability to interpret observations of white dwarfs in close binary stars. RR Cae is a binary star in which an M-dwarf eclipses a low-mass white dwarf every 0.3037 days. This makes it possible, in principle, to measure a precise, model independent mass and radius for the white dwarf. In practice, this can only be done with lightcurves obtained at infrared wavelengths because i. flaring and star-spots from the M-dwarf distort the lightcurve at optical wavelengths and ii. the depth of the eclipse due to the transit of the white dwarf becomes undetectable at optical wavelengths. We will use Spitzer to obtain lightcurves at 3.6um of RR Cae. These lightcurves together with spectroscopic data already obained will be used to measure the mass and radius of the white dwarf to an accuracy of better than 1-percent. This will be the most precise reliable mass and radius measurement made for any white dwarf to-date. This level of precision is essential to make a useful estimate of the thickness of hydrogen layer on this white dwarf. RR Cae will also be a benchmark object for testing model atmospheres of cool white dwarfs because the surface gravity and effective temperature will then be known independently of the analysis of the spectrum. These observations are essential for the accurate interpretation of data for many types of white dwarf, including white dwarfs accreting metals from from the dust discs detected by Spitzer; cool white dwarfs used for measuring the age of globular clusters and the hundreds of white dwarf binaries identified in SDSS data. RR Cae is the only white dwarf known where data of this quality can be obtained.

Spitzer Space Telescope - General Observer Proposal #60055

Direct Observation of Circumstellar Clumps in High Mass X-Ray Binaries

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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 12.5
Proprietary Period: 365

Abstract:
The direct observation of clumpy circumstellar material in high mass X-ray binaries (HMXBs) is proposed. We propose to observe the two HMXBs V420 Aur and LS 5039, based on our optical data obtained over the past four years. With precision time- series photometry from the post-cryo IRAC instrument we expect the following scientific return: (i) Characterization of the size and distribution of circumstellar clumpy material as derived from modeling the light curve variations produced as the clumps disappear behind the star. (ii) Characterization of the temperature of the clumps as inferred from the 3.6 - 4.5 micrometer color of the clumps disappearing behing the primary star. (iii) Serendipitous observation of clumpy accretion events produced as clumps heat up on their way to accretion on the neutron star or black hole.



Spitzer Space Telescope - General Observer Proposal #60108

First Multi-Orbit Time Series Observations of Jets in Ultracompact X-ray Binaries

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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 22.0
Proprietary Period: 365

Abstract:
Jets are a ubiquitous feature in many different astrophysical objects. They are found in extragalactic sources such as quasars and active galactic nuclei, in Galactic X-ray binary systems, and in newly forming young stellar objects. While the occurrence of jets is clearly connected to accretion processes in all of these objects, the exact mechanism for initiating the outflow and the roles specific parameters play in these wildly different sources are poorly understood. We propose to explore jet properties in the physically smallest systems among the XRBs, the ultracompact XRBs. The known ultracompact XRBs harbor a neutron star accretor and have orbital periods of less than an hour, requiring non-main sequence donor stars (typically a C/O white dwarf). The formation rate of ultracompact XRBs could be higher than that of hydrogen-rich (i.e., main sequence donor) XRBs, making them a significant - if currently poorly sampled - part of the Galactic population of interacting binary stars. Ultracompact XRBs are important to jet studies, because they expand the parameter space in physical size and chemical composition compared to XRBs with main sequence donors. The main focus of our observing program is to, for the first time, study the behavior of an XRB jet across several orbital cycles, by obtaining mid-infrared light curves of the ultracompact XRBs 4U 0614+091 and 4U 1626-67. Our observations are designed to characterize both orbital variations and long-term secular variations. No similar studies of jets in normal XRBs have been carried out because of lack of persistent jets, need to observe in the mid-IR, and prohibitively long orbital periods (several hours to tens of days). Because of their short periods, ultracompact XRBs are the only XRBs that allow continuous study over several orbital cycles. Currently, we only know what XRB jets look like in instantaneous snapshots; we do not have any information about their orbitally-resolved behavior. This Spitzer program will remedy that unfortunate situation.

Spitzer Space Telescope - General Observer Proposal #60197

Detecting the remnant of a hot disk that is gone

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Science Category: compact objects
Observing Modes: IracPostCryoMap
Hours Requested: 0.7
Proprietary Period: 365

Abstract:
An hot disk surrounding a millisecond radio pulsar in a binary system is identified in optical spectroscopic observations. The disk existed in a year and then disappeared before 2003 January. The disappearance of the disk was likely caused by its interaction with the radio pulsar. Different scenarios have been suggested for the interaction between pulsars and their disks. This binary system thus serves as a rare case that we would like to study in detail, helping our understanding of the interaction. Here we propose Spitzer/IRAC imaging of the binary system. We seek to detect excess emission from the remnant of the disk. A detection would suggest that the disk was pushed away and the remnant would exist as a circumbinary disk. For a non-detection, we would set a constraint on the existence of any dust material in the system, helping our near-future studies of this rare system at optical and infrared wavelengths.



Spitzer Space Telescope - General Observer Proposal #60166

Late-Time Light from Type Ia Supernovae

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Science Category: extragalactic stellar studies
Target of Opportunity: Yes
Observing Modes: IracPostCryoMap
Hours Requested: 18.0
Proprietary Period: 365

Abstract:
We propose to study the physics of type Ia supernovae at late and very-late phases of their evolution. Type Ia events produce radioactive elements that keep the expanding debris glowing for years after the explosion. Between one and three months after maximum, nearly all type Ia events have identical colors in optical bands: the Lira law. This is surprising and useful as it is not predicted by models but empirically allows dust reddening to be reliably measured. The colors in the infrared are not as well known and we propose to obtain multi-band light curves of three type Ia events during this 'Lira law' phase. These will be low-impact ToO observations triggered near maximum light with observations 5 weeks later. At very late times (>200 days) the supernova light is driven by positrons from the radioactive decay and the light curve becomes sensitive to the magnetic environment in the debris. As the type Ia ages, near-IR data suggest that more and more of the luminosity comes out at long wavelengths. We propose to observe SN2008Q and another nearby supernova to determine the fraction of bolometric luminosity coming from the mid-IR. These observations will be supported with an extensive network of ground-based telescopes.

Spitzer Space Telescope - General Observer Proposal #60198

A Double Planetary Occultation By the Outer Gas Giant Neptune

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Science Category: planets
Observing Modes: IracPostCryoMap
Hours Requested: 11.3
Proprietary Period: 365

Abstract:
As a large number of giant exo-planets are being characterized and discovered, the need to understand how gas giants respond to the circumstances of variations in insolation is becoming apparent. The gas giants in our own solar system have not been observed in sufficient detail or over sufficiently long time scales to understand how they respond to seasonal changes. A sensitive trace of seasonally driven atmospheric global evolution is provided by observations of stellar occultation events, which yield nearly instantaneous atmospheric pressure-height profiles at critical seasonal junctures. We propose to observe two of these occultation events of the outer gas giant Neptune, which has recently undergone its summer solstice. The events are nearly consecutive, and viewable only from the SST using IRAC?s sub-array capabilities and fortuitous band-pass in the shortest wavelength channel.



Spitzer Space Telescope - General Observer Proposal #60050

Smog Check for Comets: Measuring cometary CO2, CO, and particulate emissions

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Science Category: comets
Observing Modes: IracPostCryoMap
Hours Requested: 46.2
Proprietary Period: 365

Abstract:
We propose to measure the CO2, CO, and dust emission from a sample of comets. This study is in the spirit of the A'Hearn et al. compilation of the OH, C2, and dust production rates for 85 comets, wherein the only widely accepted, physically-based taxonomic types of comets were identified. Specifically, C-chain-poor comets, which are predominantly dynamically short-period comets that formed in the Kuiper Belt, are distinct from the C-chain-rich comets that tend to be long-period comets arriving from the Oort cloud and having formed formed in the Jupiter-Saturn region. Spitzer/IRAC observations are unique in their sensitivity to CO2 and CO gas. CO and CO2 have prominent spectral bands that fall within IRAC channel 2, while dust strongly dominates IRAC channel 1. Despite being the second and third most abundant compositions of cometary ice, their high abundance in the Earth's atmosphere makes ground-based observations exceptionally difficult.

Spitzer Space Telescope - General Observer Proposal #60155

IRAC Reflectances of Cold Classical KBOs and Centaurs

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Science Category: Kuiper belt objects
Observing Modes: IracPostCryoMap
Hours Requested: 108.5
Proprietary Period: 365

Abstract:
We propose to measure reflected fluxes of 22 Centaurs and 27 cold classical Kuiper belt objects (KBOs) with IRAC in order to determine surface compositions. The small bodies of the outer solar system provide probes of the statistical conditions, history, and interactions in the solar system. We focus in this proposal on two groups that isolate two key aspects of the complicated larger puzzle: starting compositions and physical effects of thermal evolution. The cold classical KBOs are the only dynamical group among the Kuiper belt that remain in (or very near) the region in which they formed (~40 AU), offering insight into the conditions in a known region of the early nebula. The prevailing hypothesis that their surfaces are dominated by complex organic molecules derived from irradiation of originally CH4-rich bodies will be directly tested by searching for strong absorption within the 3.6 micron channel. A subset will also be observed at 4.5 microns as a measure of other volatiles (e.g., residual CH4, CO2, N2) informative of original compositions. The Centaurs have been scattered inward into their unstable orbits among the giant planets. While closer to the Sun, accelerated thermal evolution is hypothesized to replace thin organic mantles with dust coatings through vigorous sublimation, creating the two distinct color groups (less red/gray and ultra-red). We will test this hypothesis by searching for and characterizing absorptions at 3.6 micron due to the hypothesized organics. The IRAC 3.6 and 4.5 micron reflectances will distinguish among multiple surface compositions that could explain the less red/gray group, only one of which (silicate dust) is consistent with the prevailing hypothesis. No other existing or near-term ground or space-based facility can measure reflectances at these critical wavelengths for these faint bodies. Our cycle-2 and cycle-4 programs to observe an initial set of outer solar system objects have been tremendously successful, and this proposal builds on that success.



Spitzer Space Telescope - General Observer Proposal #60184

Probing Planetesimals in the Solar System: Ice and Organics in Kuiper Belt Binaries

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Science Category: Kuiper belt objects
Observing Modes: IracPostCryoMap
Hours Requested: 14.1
Proprietary Period: 365

Abstract:
We are proposing to use IRAC ch1 to obtain 3.6 um albedos for a sample of 9 Kuiper Belt binaries. Binaries offer the crucial advantage of linking spectrophotometric properties to physical properties including mass, albedo, density, and internal structure. We have selected targets with known orbits and with the most available ancillary data to get the maximum leverage for the new IRAC data. Our targets are nearly equally divided between the physically and dynamically distinct Cold population and assorted representatives of the dynamically Hot populations of the Kuiper Belt. We have also limited our sample to the less-processed, more-pristine 100-km-class objects that make up the vast majority of the Kuiper Belt that have been largely left out of earlier studies. These objects may be relatively unaltered since the end of planetary accretion in the protoplanetary disk and thus anearly direct link to the earliest epoch of the solar system and, by extension, to other planetary systems. The 3.6 um band of IRAC ch1 is a sensitive detector of both water ice and solid organics in Kuiper Belt objects.The surfaces of 100-km-class objects are likely a minimally processed mixture of silicates, water ice, and solid organics. Because the 3-4 um window contains strong absorptions, both from water ice and organics, a single IRAC photometric point, when combined with optical and near-IR data, can help constrain the range of possible compositions and microphysical textures for these objects.

Spitzer Space Telescope - General Observer Proposal #60012

The Warm Spitzer NEO Survey: Exploring the history of the inner Solar System and near Earth space

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Science Category: near-Earth objects
Observing Modes: IracPostCryoMap
Hours Requested: 500.0
Proprietary Period: 0

Abstract:
The majority of Near Earth Objects (NEOs) originated in collisions between bodies in the main asteroid belt and have found their way into near-Earth space via complex and little understood dynamical interactions. This transport of material from the main belt into the inner Solar System has shaped the histories of the terrestrial planets. However, despite their scientific importance, key characteristics of the NEO population --- such as the size distribution, mix of albedos and mineralogies, and contributions from so-called dead or dormant comets --- remain largely unexplored; some 99% of all presently known NEOs are essentially uncharacterized. Recent evidence suggests that the size distribution of NEOs may undergo a transition at 1 km, and that the smaller bodies may record fundamental physical processes that are presently occurring in the Solar System but not understood. We propose to use the unique capability of Warm Spitzer to observe 750 NEOs. We will measure the size distribution of this population to understand fundamental physical processes that occur among the small bodies of our Solar System. We will measure the fraction of NEOs likely to be dead comets, with implications for the flux of organic material onto the Earth. We will measure the albedo distribution of NEOs, which indicates the compositional diversity among these small bodies. We will study properties of individual NEOs, including their surface properties and potentially their densities, and detailed properties of a subset of well-characterized objects. Our expert team and our previous experience in this field allow us to complete a comprehensive study of the origin and evolution of the NEO population. Our work is nothing less than an exploration of the history of near-Earth space.