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LSST SPECIAL PROJECT FOR MILKY WAY AND MICROLENSING SCIENCE

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ABSTRACT

Here we outline the many areas of science that would greatly benefit from an LSST Special Project that targeted the Milky Way Bulge and Galactic Plane. We explore possible survey strategies which maximize the scientific return for a number of fields including microlensing, variable stars, transients, X-ray binaries and planetary transits.

Keywords: milky way, microlensing, stars: binaries: general, stars: brown dwarfs, stars: variables: general, stars: supernovae: general, stars: oscillations, planets and satellites: detection

1. INTRODUCTION AND SCIENCE GOALS

LSST has an opportunity to make a massive impact on a wide range of stellar and planetary astrophysics by incorporating Galactic Plane fields into its survey strategy.

A Special Project to survey this region of the sky is particularly important and timely. The baseline main survey strategy neglects the Galactic Plane, covering it only at low cadence (see Fig. 1) owing to concerns that the confusion limit would occur at brighter magnitudes due to the high density of stars in these fields. Though the densely-populated fields of the Galactic Plane initially seemed to present a daunting data reduction challenge, there is growing realization that this need not obstruct the potential science yield. Furthermore the WFIRST missions contemporaneous survey of the Galactic Bulge raises present unique science potential from coordinated observations. In this White Paper, we explore the following science goals which would be yielded by an LSST Special Project in the Galactic Plane:

- Microlensing in the Galactic Plane (i.e. outside the Bulge)
- Wide binaries, repeating microlensing events
- Compact Object microlensing, dark matter
- Mesolensing
- Planetary lensing (in the Bulge)
- Bulge Globular clusters
- Complementary science to WFIRST
- Red giant variability
- Transiting exoplanets
- New short-timescale transients
- Accretion/outflow in X-ray binaries
- Dwarf Novae and Type Ia SNe
- Thick-disk structure (RR Lyrae), ISM (RR Lyrae)
- Cosmic string detection
- Variability in Ultra-cool dwarfs

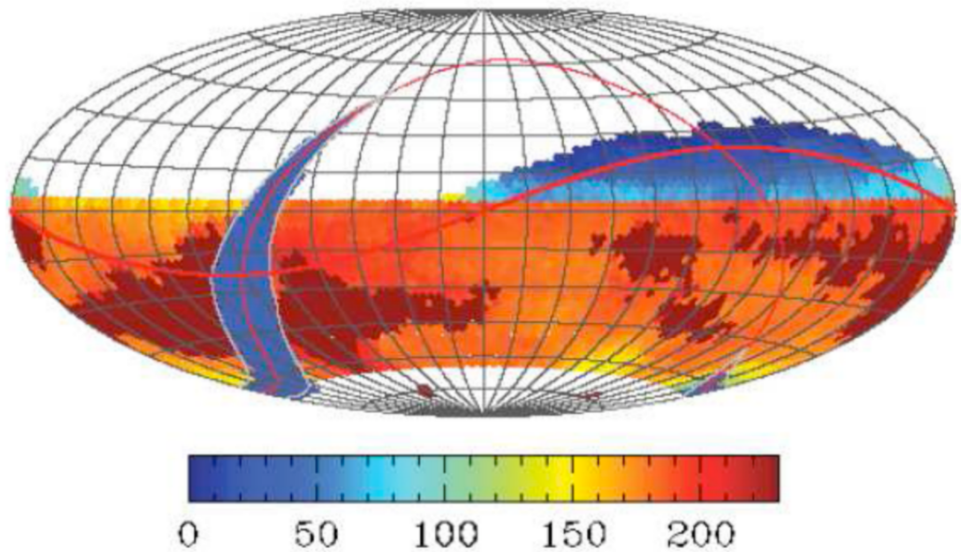

Figure 1. From the LSST (2009): The number of r-band visits to different regions of the sky over the course of the 10-year baseline main survey. Red lines represents the Ecliptic Plane and the Galactic Equator.

2. DETAILS OF MAIN SCIENCE GOALS

2.1. *Microlensing in the Galactic Bulge and WFIRST*

Surveys for microlensing events in the Galactic Bulge, such as OGLE (Udalski et al. 2003) and MOA[ref], have now been running for 25 years, provide a wealth of experience from which to draw in analysing data from these crowded fields. One of their main science drivers is the discovery of exoplanets orbiting their host stars at radii of 1-10 AU, as well as free-floating planets.

One of our most powerful tools for understanding planetary formation is to compare the planet population predicted by simulations with that found in nature.

Fig: mass .vs. semi-major axis, real detections + overlays?

Despite the outstanding discoveries of exoplanet surveys to date, Figure 2 illustrates that important gaps still exist in our census of the population. The distribution of low-mass planets in orbits between 1-10 AU is of particular interest, where the core accretion mechanism predicts a population of icy bodies (e.g. Ida & Lin (2013)). However, this regime coincides with a gap in the sensitivity of the planet-hunting techniques (radial velocities, transits, direct detection, astrometry) used to date, leading to it being sparsely sampled. Microlensing offers a way to complete the census, as it is capable of detecting planets down to 0.1 MEarth at orbital separations of 1-10AU. Moreover, since the technique depends simply on the gravity of the lensing system, it is capable of probing for unbound, free-floating planets.

To date, the vast majority of microlensing events have been found by ground-based surveys using 1–2m class optical telescopes to survey a ∼29 sq. deg. region in the Galactic Bulge with a cadence between ∼15 min^{-1} to 1 day^{-1} in I-band (lower cadence in V). ∼2000 events are alerted per year, of which typically ∼5–10 per year are found to show signs of planetary anomalies [refs?]. Events typically last between 1–200 d, with binary lensing systems being distinguished by anomalous lightcurve features which last minutes-hours.

The mass of the lensing system, M_L, can be measured as a function of the angular Einstein radius, θ_E and the parallax, π_E. The Einstein radius is normally constrained using the parameter ρ, the angular size of the source scaled by θ_E, which can be measured from the ratio of the source and Einstein radius crossing times, (t_S, t_E): $M_L = \frac{c^2 AU}{4G\theta_E \pi_E}$, $\rho = \frac{\theta_S}{\theta_E} = \frac{t_S}{t_E}$.

Observationally, this makes it essential to determine both the angular size of the source star, and the parallax to the event.

Since microlensing source stars are typically too faint for spectroscopy, multi-filter photometry is used to obtain a photometric spectral type, from which the stars radius can be derived based on stellar models. Since stars are heavily blended in the Bulge, a linear regression is performed on time series multi-filter photometry using the microlensing model in order to distinguish the flux from the source from that of the blended stars. For this reason, time series, multi-band photometry of the type LSST will deliver is essential for microlensing analysis.

There are a number of ways of measuring the parallax to microlensing events. For events with t_E >30 d, the Earths orbital motion is often sufficient to produce a measurable skew in the lightcurve. In the case of rare, very high magnification events, it is possible to measure terrestrial parallax; an offset in the time of the peak as seen from geographically-separated observatories. The most general technique however, is to obtain simultaneous time series photometry from both Earth and a space-based observatory separated by ∼0.5 AU, since this allows the physical properties of almost all lenses to be measured.

That NASAs WFIRST mission (launch: mid-2020s, 5 yr duration) will be operating during LSSTs Main Survey therefore represents a rare opportunity for to observe the same events from the ground and space, enabling the parallax signature to be measured. Furthermore, LSST can provide much-needed long-baseline time coverage. Due to practical constraints, WFIRST will survey the Bulge continuously for annual, 72d windows **Fig 3: simulated WFIRST lightcurve?**. This leaves gaps in the lightcurves of several months, potentially compromising the measurement of parallax and certainly missing lightcurve features, unless the additional observations are provided. In this respect, LSST is well placed to ensure that all features of these events are well characterized by delivering the necessary long-baseline photometry through a coordinated survey of the same fields.

2.2. *Microlensing in the Galactic Plane*

Microlensing is an intrinsically rare phenomenon, since it relies upon the chance alignment of unrelated stars. As an individual stars probability of lensing or microlensing optical depth (averaged over the whole sky), τ, is ∼1x10^{-8} [ref], surveys need to monitor millions of stars in order to ensure detections. Traditionally, surveys with ∼0.5–1 deg fields of view had to concentrate on regions of high stellar density (such as the Galactic Bulge) to achieve the star counts needed. LSST stands to change this paradigm, making it possible to survey a vastly larger area of sky to sufficient cadence. Han (2008) estimated the microlensing rate for surveys outside the Bulge, and predicted that if a survey reached $I_{\rm Limit} \sim 18$ mag and surveyed 8.0×10^7 stars, it would detect 21.20 events per year across the whole sky. LSST can monitor the majority of stars in Earths side of the Galaxy since its sited in the southern hemisphere while also reaching deeper limiting magnitudes, implying a significantly higher rate. By exploring beyond the Galactic Bulge, LSST will diversify the types of events discovered. Han found that as the number density of potential lenses decreases in fields away from the Galactic Plane, the average distance of detected lenses and sources grows smaller, meaning that LSST will probe for dark objects closer to the Sun (note also that Hans simulation did not include brown dwarf or free-floating planet populations). He also found that events at lower latitudes tended to have longer timescales due to the galactic velocity distribution - which is not only more conducive for discovery by LSST but also makes it more likely that the parallax can be measured from its lightcurve.

2.3. *Intermediate Mass Black Hole Microlensing*

The discovery of gravitational waves from merging intermediate mass black holes by LIGO is arguably one of the most important scientific discoveries of the 21st century (Abbott et al. 2016). While it is an important confirmation of general relativity, the greatest impact of this discovery is likely to come from answering the questions it has posed. For example, what is the abundance of intermediate mass black holes? This question is of potentially fundamental importance. The current rate of LIGO events favors such a large abundance that intermediate mass black holes, or intermediate mass massive compact halo objects (IM MACHOs; $15 - 10^5\,{\rm M}_\odot$), would make up the majority of dark matter (DM) (Bird et al. 2016), although with admittedly large uncertainty. LSST holds the potential of making one of the best and most direct measurements of IM MACHOs via gravitational microlensing (avoiding complexities and associated systematics that plague other means of constraining the IM MACHO mass range; e.g., CMB, wide binary star, and dwarf galaxy constraint).

This general concept has been proven feasible by microlensing discoveries of black holes at the low end of this mass range (Wyrzykowski et al. 2016; Bennett et al. 2002). We can extend the microlensing to higher masses using the paralensing (or microlensing parallax) signal. This approach, and in particular with LSST, has been recommended as a means of constraining possible dark matter candidates by 200+ Department of Energy high energy physicists in the Cosmic Visions: New Ideas in Dark Matter report (Battaglieri et al. 2017).

Regardless of the nature of DM, such an LSST microlensing survey can also answer a number of other outstanding questions regarding IM black holes and their formation. For example, by providing an estimate of the mass spectrum slope and peak location we can gain insight into their formation history. In particular, were they formed as a result of stellar evolution (e.g., mergers of smaller remnant black holes (Elbert et al. 2018) or massive stars collapsing to black holes without becoming supernovae (Adams et al. 2017)), or were IM MACHOs formed as a result of violent space-time fluctuations occurring during the first moments of the Big Bang (Chapline 1975)? In each of these science cases we expect the signals to vary as a function of local environment, which is one of the important reasons for surveying the Bulge, LMC, and SMC. Microlensing is complementary to LIGO since it is capable of directly measuring the properties of free-floating, as well as binary, black holes in our Galaxy. In addition to their location, we can directly measure the mass of individual black holes mass by combining the paralensing signal as measured by LSST with follow-up measurement of the astrometric microlensing signal (Yee 2015) from future extremely large telescopes (e.g. GMT, TMT, ELT).

Because of the long timescale of IM MACHO lensing events (on the order of months to years) this science can be carried out in parallel with other microlensing and time variable surveys with little impact to those surveys. For example, surveys that require a much higher cadence (e.g. planetary microlensing surveys) can accomplish their science plus the IM MACHO science by substituting a single contiguous long high cadence survey with chunks of shorter high cadence surveys spread out over the course of the LSST survey. It is also complementary to other time variable surveys since, as previously noted, there is an advantage in looking along different lines-of-sight (e.g. Bulge, LMC, and SMC).

2.4. *Microlensing by Wide-binaries*

Large scale microlensing surveys have been successfully carried out for more than two decades. From initial investigations into the nature of dark matter (Alcock et al. 2000) to a more recent focus on exoplanet detection (Bond et al. 2001; Udalski 2003; Bond et al. 2004), these surveys have detected thousands of microlensing events. Of these events, the majority have been attributed to single, point-mass lenses, located towards the Galactic bulge. A small fraction have been binary lens events, revealing the presence of nearby stellar and planetary companions in close orbit. However, given most solar-mass (and above) stars exist in binaries **(Insert ref.)**, and most of these have planets around them (Cassan et al. 2012), an interesting question is whether many of these seemingly single lens events are actually widely separated binaries.

Theoretical predictions for the expected signatures of wide-binary lenses have long since been known (Di Stefano and Mao 1996). A typical close-binary – the type more commonly observed by surveys thus far – can be thought of as two point-mass lenses with overlapping regions of magnification. As the separation between the two lenses increases, the regions of magnification no longer overlap and an observer would see two distinct brightenings with an intermediate period where the source star returns to baseline magnitude. In effect, the event would appear to "repeat" – as described by Di Stefano and Mao (1996). The time delay between these periods of amplification is proportional to the orbital separation of the two components of the lens; it may be on the order of weeks, to years, depending on the precise characteristics of the lens system.

More formally, a binary lens is generally considered "close" if the separation of the components, a, is $\sim 1 - 4R_E$, and "wide" if $a > 4R_E$.

An important point in the case of a wide-binary lens is that the amplification of the two events will not be the same. The angular separation from the source star will be different for each component of the lens in all but the rarest of alignments: the result of this is that the amplification from one component will be much weaker than the other.

Whilst the theory has long been established, technical limitations of current-generation microlensing surveys means that <30 wide-binary events have been detected thus far (Skowron et al. 2009; Ryu et al. 2010; Han et al. 2017). The low amplification associated with the outer lens means that deep, high quality photometry is required to probe down and extend the detection threshold to fainter magnitudes – a task to which LSST is extremely well suited.

Sufficient detections of these events would provide an independent channel for statistical analyses of binary star properties. Of particular importance is the possibility to extend the mass ratio distribution function out to larger separations where typical spectroscopic methods are ineffective due to low radial velocities. Perhaps even more important is the opportunity to detect planetary objects in wide orbits (Di Stefano and Scalzo 1999a,b; Di Stefano 2012), and novel systems with multiple lenses (Poleski et al. 2014). Observations in this regime would play a key role in constraining planetary formation theory in a sparsely sampled region of parameter space, which is uniquely accessible by microlensing.

2.5. *Mesolensing*

Current microlensing surveys focus on regions of high stellar density – such as the Galactic bulge and Magellanic Clouds – in order to maximise the event rate over a limited region of sky. A typical microlensing event in this scenario consists of a M-dwarf star ($\sim 0.5 M_\odot$) at a distance of ~ 6 kpc, lensing a background star in the Galactic bulge at a distance of ~ 8 kpc, over a timescale of ~ 20 days.

The event rate, $\Gamma(\theta_E, \mu_{rel}, N_*)$, where θ_E is the angular Einstein radius, μ_{rel} is the relative velocity of the lens, and N_* is the number of background source stars being monitored. θ_E determines the area of sky which is sensitive to a specific lens and goes as ${M_L}^{1/2}$ and $\sim {D_L}^{-3/2}$ – the lens mass and distance, respectively. Hence, for high mass or nearby lenses, θ_E increases. The combination of θ_E and μ_{rel} defines the arc of sky which is sensitive to lensing over a given time. Since nearby lenses tend to have higher relative velocities than bulge lenses, this combination of larger θ_E and μ_{rel} sweeps out a larger region of sky where lensing can occur. Thus, whilst the overall event rate is still highest in dense fields, the probability of a specific object acting as a lens is higher for nearby ($\lesssim$ 1 kpc), high velocity lenses than a similar object located in the bulge. This regime of high probability lensing is known as "mesolensing" (Di Stefano 2008a,b).

Hence, provided a wide region of sky can be monitored over a sufficiently long timescale, mesolensing is expected to occur even in regions where the microlensing optical depth is low (Di Stefano 2008a). The outer quadrants of the Galactic plane (in addition to the inner quadrants and bulge), M31, other galaxies in the Local Group, and beyond, can serve as a suitable background for mesolensing (provided the photometry is sufficiently deep) – all of which is estimated to increase the area of sky sensitive to lensing by at least an order of magnitude over current microlensing programs. Therefore an all-sky survey such as LSST is ideally suited to detect these types of events during its decade-long observing program.

Typical lenses would include local stellar populations, but more importantly, dark, dim objects such as low mass dwarfs, stellar remnants, and free-floating planets (Di Stefano 2008b). This presents an opportunity to investigate the mass distribution in the local neighbourhood – including away from the Galactic bulge – which would provide important feedback to stellar, planetary and galactic theory by probing a different region of parameter space from traditional microlensing events.

2.6. *Bulge Globular clusters*

Globular clusters (GCs) contain some of the oldest stellar populations in the Galaxy and are rich in RR Lyrae stars, which are commonly used as standard candles to measure distances. By studying their ages, metallicities and distances, it becomes possible to address a number of astrophysical problems, such as the dynamical and physical conditions at the early stages of formation of the Galaxy, and stellar structure and evolution (Krauss & Chaboyer 2003; Roediger et al. 2014). Of the 158 GCs currently known in the Milky Way, between 20 and 40 are thought to be associated with the Galactic bulge (Minniti et al. 2017).

Globular clusters in the bulge have not been extensively studied because photometric accuracy is compromised due to high reddening and differential extinction by foreground dust (Bica, Ortolani & Barbuy 2016; Tsapras et al. 2017). However, they are particularly interesting to explore with LSST's high-resolution, deep multi-band photometry, since they can provide reliable estimates of the extinction toward the bulge, highly accurate color-magnitude diagrams, as well as accurate distance and metallicity measurements for the inner parts of the Galaxy (Bobylev & Bajkova 2017). These results can then be compared with similar studies of halo clusters and used to calibrate models of Galactic formation and evolution (Binney & Wong 2017).

2.7. *Variability in Ultra-cool dwarfs (UCDs)*

Photometric monitoring of brown dwarfs has shown that these objects show a time-dependent variability. The general theory is that this variability is due to global weather phenomena in the atmosphere. This observation has initiated the beginning of an insight into weather patterns in substellar objects outside of our Solar System. While cloudy atmospheres could explain the observed variabilities, see e.g. Marley et al. (2010), many problems can only partially be explained, as e.g. resurgence of FeH absorption.

Therefore other theories have been brought forward. One theory argues for non-uniform temperature profiles or perturbations in the atmosphere's temperature structure causing brightness fluctuations in UCDs (Robinson & Marley 2014). Another theory by Tremblin et al. (2016) argues for thermochemical instabilities that cause the observed variability in UCDs. Chemical abundance variations can form non-uniform surface opacities causing variabilities in the observation.

Further variability effects might be introduced through lightning and auroral activities. Several works by amongst others, Helling et al. (2013), Bailey et al. (2014) and Hodosán et al. (2016) discuss the possibility and detection of lightning effects in the BD's atmosphere. While the possible detection of lightning has been discussed theoretically, auroral activities in a BD have been detected by Hallinan et al. (2015). Finally, a favorable alignment between a putative planetary orbit and the observer's line of sight could cause a periodic transit-shaped variability (for details see [**Reference to transit section**]).

However, the sample of substellar objects monitored for variability is still very small to draw a meaningful conclusion. In addition, the difficulties to detect and monitor these objects shows the example of Luhman 16 AB, which is the closest substellar object not belonging to our Solar System. Despite being very close to us, it was discovered only recently in 2013, but on the other hand, it has also become a benchmark system (see e.g. Street et al. (2015), Buenzli et al. (2015) and Karalidi et al. (2016)) to study variabilities in brown dwarfs.

A major problem of these objects is their low intrinsic brightness. However, only a few variability surveys have been conducted, most of them in the NIR bands. Unfortunately, the difficulties to obtain high-precision light curves in the NIR wavelength range combined with a short observations span hampered a robust conclusion. So far, the longest observing span has been done by Street et al. (2015). The authors observed Luhmann-16 in the optical band with the LCO 1-m telescope network for 42 days. Instead observing confirmed UCDs one-by-one, we will take advantage of LSST's very huge etendue. This will allow us to observe many of these faint UCDs with a large range of spectral type. We will be able to monitor many objects for a larger range of time then just a few hours. Given the faintness of these objects and the planned photometric precision of LSST, this facility will be the perfect way to photometrically monitor many UCDs at once in an efficient way. Moreover, the large aperture of LSST will permit to extent a robust sample of monitored UCDs down to even cooler spectral types, as e.g. Y-type.

The discovered and monitored objects will help us to gain a better understanding of cool atmospheres. Furthermore, they will serve as precursor for atmosphere studies with the future generations of gigantic telescopes and advanced space missions.

Besides, probing the atmosphere of UCDs we will also extent and improve the statistical significance of the IMF of UCDs in the galactic plane. This region has been avoided in the past due to crowding and increased confusion with other objects, like e.g. O-rich and C-rich Long Period Variable (LPV) asymptotic giant branch (AGB) stars, distant highly reddened luminous early-type main-sequence/giant branch stars and Young Stellar Objects (YSOs). However, these objects are shared with other group members [**see other science drivers**], as opposed to pure UCD surveys, where these objects are simply rejected. Therefore, only few limited searches for UCDs in the galactic plane has been conducted, see e.g. Reid (2003), Phan-Bao et al. (2008) and Folkes et al. (2012). All authors confirm a similar space density of UCDs as in higher galactic latitudes (see e.g. Cruz et al. (2005)).

2.8. *Transiting Exoplanets*

A number of surveys have been carried out to search for transiting exoplanets, however the vast majority of these planets have been detected by the *Kepler* mission, resulting in almost 5,000 transiting planet candidates. While this has provided very useful constraints for stars of roughly solar mass, age, and metallicity, the understanding of the frequency of exoplanets around other stellar populations has been substantially more limited. LSST provides the opportunity to understand the frequency of transiting exoplanets around numerous stellar populations, including red and white dwarfs and stars in clusters and the Galactic Bulge.

2.9. *Cataclysmic Variables in the Galactic Plane*

Cataclysmic variables, close binaries with a white dwarf acccreting from a late main-sequence star, constitute a significant source of both periodic and transient phenomena associated with the endpoints of stellar evolution. They include novae, dwarf novae and novalikes, all thought to be part of a long term evolution cycle with novae (formed through thermonuclear events on the surface of massive white dwarfs) occurring at intervals of thousands of years, while in-between they are novalikes (steady high mass transfer times) or dwarf novae (disk instability caused outbursts occurring on timescales of 1 week to 30 years based on the mass transfer rate). Because the white dwarfs are the most common end-product of a low mass main-sequence star, these binaries are the most common in our galaxy and their correct numbers are necessary for a complete understanding of stellar evolution. They also constitute possible progenitors for SN Ia.

However, most past surveys have avoided the Galactic plane for ease of source confusion, whereas the density of CVs should be about 1000 times larger in the plane compared to the Halo. ZTF plans to cover the plane visible from the northern hemisphere (2940 deg^2) with 3 hrs of continuous coverage in g band in each field to uncover the shortest orbital period systems. LSST will have the advantage of the southern hemisphere, fainter magnitudes and more time coverage of a given field. Short cadence observations can reveal orbital periods (population models of Goliasch & Nelson (2015) predict the majority of systems should have orbital periods near 80 min), while longer time coverage will reveal dwarf novae through outbursts (rise times of 0.5-1 day, length 2-30 days) or novae (rise of days, length of weeks-months). Previous x-ray, optical studies of a low extinction region in the bulge at 1.4 deg south of the galactic center (Hong et al. 2012) revealed it contains a large population of CVs containing a highly magnetic white dwarf and these may constitute the majority of low luminosity x-ray sources in the bulge. These sources had R mags of 20-24 with periods of 1-4 hrs.

3. SURVEY STRATEGIES

3.1. *Microlensing in the Galactic Bulge*

Current ground-based microlensing surveys reach $I_{\rm limit} \sim 24\,$mag, observe annually Feb-Oct. LSST easily reaches similar magnitude limits in shorter exposures, allowing it to survey the region in more filters, thereby providing better constraints on the Spectral Energy Distribution (SED) of the host stars and correspondingly better characterization of the physical properties of the lensing system. WFIRST will observe in NIR in 72 d windows from L2 from mid-2020s - meaning a special project later in the LSST program. Filters: R (orange), Z, Y, J, H, wide and GRS. Field of view of microlensing program: 7 x 0.8x0.4 deg FOV, 0.11 arcsec/pixel

3.2. *Intermediate Mass Black Hole Microlensing*

As with other microlensing science cases the chances of observing an event is approximately proportional to the number of stars survyed, thus it is most efficient to survey fields of high resolved stellar density. As noted in §2.3 various intermediate mass black hole science cases can be improved by looking both in the plane of the Milky Way towards the bulge and out of the plane towards the LMC and SMC. To leverage the achromatic nature of lensing for descriminating against background stellar variability, such a survey requires at least two bands. There is an advantage in observing with redder, high throughput bands (e.g., r and i). They are less sensitive to galactic extinction when surveying the bulge, and suffer fewer differential chromatic refraction (DCR) effects (see e.g. https://dmtn-037.lsst.io). To leverage the paralensing signal it is important to survey the fields when the parallax signal can be maximized. Since the timescale of intermediate mass black hole microlensing events last on the order of months to years it is important to extend the survey of the entire period of the LSST survey.

3.3. *Bulge Globular clusters*

RR Lyrae stars typically have periods ranging from 0.1 to 1 days. ~11 pointings can cover ~34 of the inner Galaxy and bulge Globular clusters. Will need to monitor over ~20-30days to cover enough periods for accurate phase folding. Which bands? Typically observed in B,V,I (so LSST griz?) for construction of deep CMDs. I,V(limited)-band OGLE data exists for many RR Lyr stars in several of these clusters and can be used for calibrating offsets.

3.4. *Variable UCDs*

Variable ultra cool dwarfs show typically variability with periods between 3-12hours. In order to sample these periods with a meaningful cadence, the same field should be observed at least with four 15 sec. exposures every 10 min. in staring mode. Previous investigations have revealed a possible phase shift and filter dependent amplitudes. It is therefore important to sample the variations in different filters. Ideally would be to observe within this 30 min. cadence in different filters, e.g. 4 $\times$ 15 sec. in y,z,i and r. Importantly, we note that this data will be the first y-band light curve. However, another possibility is to stick to one filter during a given night and observe the same field on different nights with different filters. This could allow to observe different fields in this 10 min. cadence. The pointing should be repeated for 5 hours on 3 consecutive nights. This whole observing procedure should be repeated each 3-5 nights.

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