SgrA* as a MECO

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20 December 2016

ABSTRACT
The final report of the NASA SOFIA/FORCAST mission to study the compact object SgrA* at the Galactic Center is a scientific report by Lau et al (2013) that shows a color translate of 3 mid-IR wavelength bands which is reproduced in the Lau paper and is central to the interpretation of the emitted radiations. Standard black hole theory did not account for the most luminous structures seen in the image and remained un-explained in the conclusions of the Lau et al paper. We show that the optical/infrared/sub-mm/radio emission is produced by the pattern of magnetic field lines originating at the surface of the compact object. The field lines terminate in the structured accretion disc which is seen to be the baryonic dark matter. Since standard black hole theory with its infinite density event horizon cannot support magnetic fields tied to the surface and rotating with it, the compact object at the galactic center is found to be the MECO variant of standard black hole theory.

1. INTRODUCTION

The SOFIA/FORCAST image of SgrA* must be understood as resolving one of the oldest dilemnas of black hole theory. If a black hole has such a strong gravitational field that nothing, not even light , can escape it, then how do quasars become the most luminous objects in the Universe? In this report we show how the strange luminous pattern, sometimes described as a spiral wave, is a prediction of the MECO alternative to standard black hole theory. This alternative theory to black hole structure began with the ECO (Eternally Collapsing Object) discovered by Mitra (1999) and was generalized with the addition of magnetic fields by Robertson and Leiter (2001) to produce the MECO (Magnetic Eternally Collapsing Object) theory used here. The application of the MECO theory to the microlensing observations of gravitationally lensed quasar Q0957+561 A,B was given by Schild, Leiter, and Robertson (2006) and Schild , Leiter & Robertson (2008) . The application of the general MECO theory to the structure at the center of our Galaxy, SgrA*, and known to be related to black holes was described by Robertson and Leiter (2006, 2010).

This report is organized as follows. Some predictions of MECO theory applied to SgrA Leiter & Robertson (2010) are given in Section 2, and a simple 3-D model construction is introduced in section 3. The model is compared to the SOFIA/FORCAST image of SgrA*, in section 4, and the polarization structure predicted within the MECO theory is compared to the measured polarization data in section 5, with predictions of what polarization structures would be expected as observation with the intercontinental EHT improve.Concluding remarks and further predictions are given in Section 6.

Section 2. The MECO Prediction of the Luminous SgrA* Structure of Robertson and Leiter (2010)

A significant prediction of the MECO theory describing the overall black hole-like structure contained an alternative to the infinite density “event horizon” of the standard black hole model due to unlimited quantum electrodynamical pair production of principally electron-positron pairs having short time duration but generating a magnetic field that follows a pattern global to the object. The magnetic field is related to the dipole global field of a simple bar magnet, and has been illustrated in Robertson and Leiter (2006), particularly in relation to the accretion disc expected to be present due to the relentless pull of gravity on all surrounding matter. We refer to this model including the accretion disc, even though the ring around the central object in the SOFIA/FORCAST image (Fig. 1) is not aligned with the plane of the Milky Way disc.

The configuration specifically calculated for the MECO interpretation of the SgrA* object has been given in Robertson and Leiter (2010), where tables for the expected magnetic moment and field strength list the physical properties calculated for the mass and bolometric luminosity of the known object. In particular, it is predicted that the central MECO photosphere should not be visible in images at short infrared wavelengths taken to monitor motions of surrounding stars used to determine the mass of $4.5x10^6$Mo where Mo is the mass of the sun.

The total luminosity associated with this mass is estimated in Lau et al (2013) to be 7x10^6 Lo where Lo is the solar luminosity. Because of the heavy extinction between SgrA* and the solar vicinity, this luminosity can only be detected at far-IR wavelengths.

Section 3. A model of the predicted luminous spiral pattern of SgrA*.

In Fig. 1 we reproduce from RL(2010) Fig 1 the pattern of magnetic dipole field lines expected for the SgrA* MECO, in relation to the co-rotation radius r_c and the magnetospheric radius r_m. Because as will be seen we do not observe a jet along the apparent rotation axis, it is not yet clear that the MECO is producing a classical jet, and therefore, the relationship of these critical structural inflow parameters to spectral states as shown for classical quasars by Schild et al(2008) is not yet defined. Note , however, that the calculations in RL(2010) were for Bondi accretion whereas the general quasars investigated by Schild et al (2008) presumed equatorial accretion disc inflow. Notice from Fig 1, however, that the field lines are approximately semi-circular, and they will be modeled as such throughout this report.

Thus whereas RL(2010) presumed Bondi accretion, the SOFIA/FORCAST image suggests that the luminous central feature appears to terminate (originate) at the luminous blobs seen in the mid-IR SOFIA/FORCAST image of SgrA*. If we assume that the observed torus is the inner accretion disc edge, and that these luminous blobs are probably partially evaporated stars or perhaps Bonner-Ebert spheres of sub-solar mass, and the evaporated gas is immediately ionized so that charged ions and electrons must follow the force-free magnetic field lines and radiate away the gravitational potential energy as synchrotron radiation of the Larmouring electrons. If we presume that the MECO rotation is in the same direction as the in-spiral accretion disc inner edge, then it is known that the heavier protons and heavier ions flow outward as in quasars, and as illustrated in RL(2010) leaving the lighter electrons in-spiraling along the force-free magnetic field lines. Most likely the outflowing wind feels a net charge at the MECO and turns around to neutralize the negative charge by infalling along the polar field lines shown in Fig 1 at distances above the Z_m(in) dotted line.

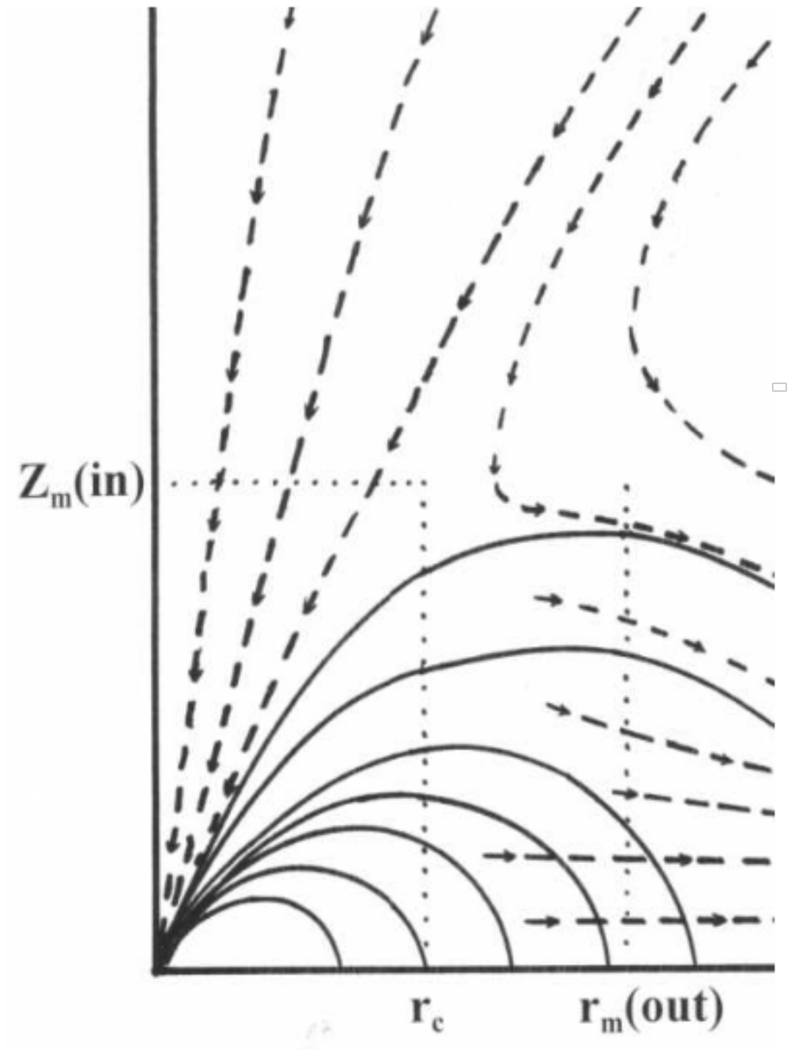

Fig. 1. The magnetic field pattern predicted by RL(2010) for the MECO model of SgrA* with a Bondi infall flow. It is presumed that the infalling material is quickly ionized by the strong X-ray flux observed at the SgrA* MECO. Labels along the abscissa axis identify the critical radii r_c, the co-rotation radius, and r_m, the magnetic radius, as tabulated in RL(2010).

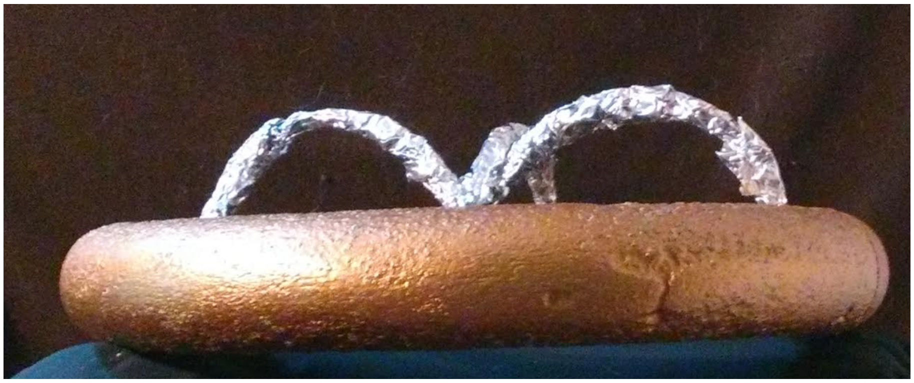

Figure 2. A 3-D model of the SgrA* structure seen in the same side-on perspective as Fig 1. In this model the luminous 3-arm silver structure of our Fig. 3 presumed to originate in synchrotron radiation of electrons originating at the blobs in the golden-brown inner accretion disc edge and traveling towards the gravitationally attractive central mass along force-free magnetic field lines in approximately semi-circular arcs. They emit 7X10^6 Lo of bolometric luminosity, which is dominated by far-IR radiation observed in the 3-arm spiral pattern as shown in Fig. 3 below

The MECO model of these structures predicts that the positive ions (protons and ionized nuclei, ionized by the abundant X-rays at SgrA*), will create an equatorial outflow wind so the magnetic propeller is seen as a giant charge separation machine, with the electrons being driven toward the MECO surface and the positive ions driven outward in an equatorial wind flow. This differs somewhat from the predicted flows shown in Fig. 1 as small arrows because the pattern envisioned in RL(2010) was from a Bondi flow gravitationally raining down onto the poles.

Because the SgrA* central object must remain electrically neutral, these charges must eventually recombine and emit a strong X-ray flux with a boosted high-energy spectrum. Notice that whereas the abunfdant quasar X-ray emission is ordinarily discussed as originating in a synchrotron self-comptonization process with no details given. It is also necessary to discuss the implications for the nature of the accretion disc implied by the image.

Comment [RS1]:

Fig. 3

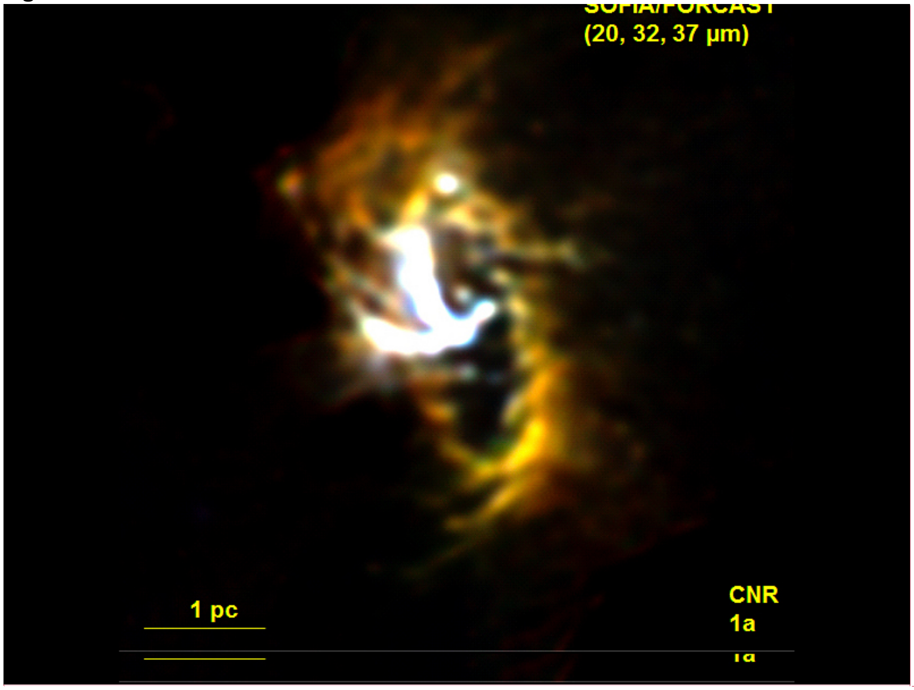

Fig. 3 The Sofia Forcast image of SgrA* is taken from the NASA web site and is a color translate made from images recorded behind filters at 20, 32, and 37 microns in the far-infrared. Thus the image shows the radiating white 3-arm structure discussed by Lau et al 2014 containing 7 million solar luminosities from a region of radius approximately 1 parsec.
Its uniform luminosity at all measured frequencies implies that it originates in synchroton radiation by spiraling electrons following force-free infall along magnetic field lines originating at the MECO surface as predicted by Robertson and Leiter (2003). An infall process dominated by synchroton radiation would have a broad spectrum indicated by its white color, and would also have a polarization signature as will be discussed in Section 5 below. Also shown in the figure is a cooler structure which we attribute to an accretion disc inner edge. It is attributed to thermal emission because it has the characteristic

Fig. 4 The 3-D model of SgrA* rotated to an angle where the 30-37 micron SOFIA/FORCAST observed accretion disc inner edge is approximately matched to the infrared data showing its thermal emission. The model torus is colored a tan color. And the luminous synchrotron emission filaments guided by semi-circular magnetic field lines converge at the dull-red sphere at the measured position of the MECO compact object.

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displays the classical thermal color-brightness correlation wherein the more luminous structures are the hottest, indicated by their bluer color.

Notice, however, that for this to be the accretion disc, the plane of the accretion disc must be tilted and almost perpendicular to the plane of the Milky Way galaxy. It also requires that the pole of the rotation must lie approximately within the plane of the Galaxy. Such an inclined accretion disc has already been indicated by several independent observations of polar inflow, including the observation of an aligned polar plane that contains all of the dwarf spheroidal satellites of the Milky Way galaxy (Kroupa et al, 2005), the polar flow discovered with the Sub-mm array (SMA), and the Sagittarius Stream. It remains to be demonstrated that all of these inclined streams are co-planar with the SgrA* torus. The plane of the milky way in the direction of the galactic center is shown by Reid et al (2004, 1999). The inclination of the ring structure in the SOFIA/FORCAST image of SgrA* is immediately apparent, and has been measured by Lau et al (2013) as 23 degrees with tespect to the plane of the sky. So our line of sight towards the galactic center must be inclined to the observed accretion disc inner edge ring. Thus in this case, the present accretion disc for the in-spiral to the compact object at SgrA* cannot be coincident with the Milky Way equatorial disc.

Also requiring understanding is the structuring of matter in the observed accretion disc edge as a collection of orbiting or in-spiraling blobs. We note in particular that if it originates in the system of dwarf spheroidal satellites of the Milky Way, then it should be dominated by baryonic dark matter, as is a known property of the Local Group swarm from the observationally inferred high M/L ratios. In particular we do not see any evidence of cold dark matter, and we see that the 3-armed luminous structure seems to terminate and originate in the largest luminous blobs in the image. This seems to be in alignment with the conclusion of Schild (1996, 2002, 2004) and Nieuwenhiizen (2003, 2016) that the baryonic dark matter (the missing hydrogen) is in the form of a vast network of planet-mass primordial structures variously called rogue planets or milli-brown-dwarfs when discovered in gravitational microlensing observations (Schild, 1996). Their primordial origin was predicted by Gibson from hydrodynamical considerations in 1996. Their mass distribution function was measured from Q0957+561 brightness monitoring observations and found to be strongly biased toward low-mass objects by Nieuwenhuizen & Schild (2012).

This population of objects appears to be somewhat resolved, and the largest ones are found at the terminus of the 3-armed luminous structures in the thermal image. We would expect that the radii set a lower limit to the thickness of the luminous arms seen in Fig.3. And because of the presumed origin of the measured luminosity in synchroton radiation it is likely to have an observable polarization signature.

5. Polarization Observations of the luminous structure in SgrA*

Observation of polarization of the radiation from SgrA* on the spatial scale of the event horizon have been given by Johnson et al (2016) but interpreted within the classical black hole theory. Their Fig. 1 shows that observations of linear and circular polarization are securely recognized but interpreted in the context of a relativistic magneto-hydrodynamical simulation, producing the conclusion that the polarization originates in chaotic motions of the emitting electrons. Their Fig. 2 (left panel_ compares the mean amplitudes of polarization with such simulations (their figure 2 right panel). And unsurprisingly the agreement is poor.

Unfortunately their map of measured polarizations does not show the locations of the polarizations on an absolute (equatorial} coordinate system so the polarization observations cannot be compared with the luminous structures in our Figures 3 and 4. Thus we are left to predict what polarization structures would be expected for the recognized structures. For this we adopt the nomenclature of Lau et al, Fig. 3 that identifies the structures as the Northern arm, the Western arc, and the E-W bar. These structures are identified in Fig. 5 which is taken from Fig. 3 of Lau et al.

To do this we identify the “northern wing” which appears to originate in a luminous blob in the accretion disc inner edge. It then traces southward in a long arc that points at the compact central object. Moreover we identify 2 additional structures which we identify as “E-W wing west and “E-W wing right” which are the luminous structures on the eastern and western sides of the compact object respectively.
Of course this is done to allow description of the 3 arms of the luminous structure separately.

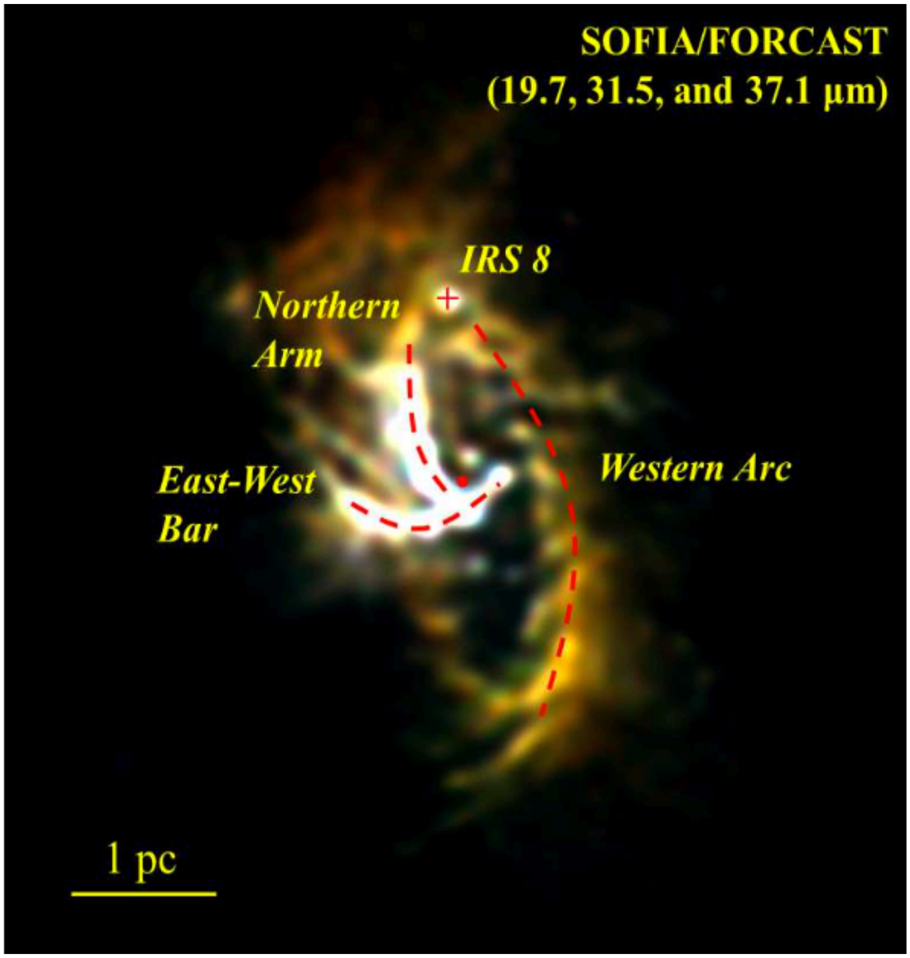
SOFIA/FORCAST
(19.7, 31.5, and 37.1 μm)
IRS 8
Northern
Arm
Western Arc
East-West
Bar
1 pc

Figure 5. The SOFIA/FORCAST image with its principal structures identified for comparison with the tilted 3-D model for intercomparison and for prediction of the polarization properties. From Lau et al (2013) Fig. 3.

We note, however, that in this rotation matched to the mid-IR image, the presumed accretion disc inner edge is not aligned with the plane of the Milky Way. In other words, the torus does not lie in the milky way plane. It is not known, however, whether the plane of the torus aligns with the planes of the Sagittarius stream or the Polar Flow structure seen in sub-mm imaging with the Sub-Millimeter Array, or with the Kroupa (2009) accretion plane defined by the dwarf galaxies of the Local Group.

For the polarization prediction we see that the Western arm appears to terminate in a blob of baryonic dark matter, and then be guided along the arm in eastern direction along force-free magnetic field lines such that at the western extremity it will show strong luminosity of forward-directed synchroton radiation with circular polarization. Farther to the east, and nearly superimposed on the compact central object the magnetic field line is nearly perpendicular to the line-of-sight and should show strong linear polarization with nearly N-S vectors. Similarly the Northern arm presents a sweeping appearance and is nearly seen in the plane of the sky, so its overall motion is nearly perpendicular to the length of its grand sweeping arc and its light should be predominantly linearly polarized. In the proximity to IRS 8 it should be predominantly seen circularly polarized and beamed towards the solar vicinity, and where the Northern Arm merges with the E-W Bar near the central compact object it should be significantly circularly polarized but beamed primarily away from the solar vicinity. Along the northern arm, it should be easy to trace a gradual rotation of the direction of the linear polarization to be always perpendicular to the flow of electrons away from IRS 8 towards the central MECO.

Thus the observation of synchrotron radiation originating in charged particle flows, presumably electrons, appears to create the complex pattern of polarization expect for partially beamed synchrotron radiation that follows the magnetic force-free lines in the rotating MECO magnetic propeller. Where the lines originate in hydrogen centrally concentrated structures the 3 principal lines are relatively more directed to the solar vicinity and the circular polarization signature should be strong. Over most of the lengths of the lines, especially where the 3-D direction of the line is nearly in the plane of the sky, the linear polarization component should be maximum and the polarization vector should be normal to the tangent of the line direction. Interestingly the helicity of the circular polarization should reverse over the length of the line, since the magnetic propeller causes the forward beamed radiation pattern to reverse by following a semi-circular arc from the line's origin at the evaporating hydrogen blob until it disappears in the vicinity of the collapsed MECO. Notice that where the 3 arms converge the beamed radiation should have the opposite helicity and hence reversed circular polarization from that observed as emission in the vicinity of the dark baryonic matter blobs at the tips of the arms.

6. Conclusions and Discussion

We conclude that the observed luminous synchrotron emission originating near the central compact MECO object at the center of our Galaxy follows the predicted emission pattern of a MECO object inside of an accretion disc. The resulting 3-armed disc pattern is understood to originate in electron flows along the force-free magnetic field lines that originate in structured and presumably centrally condensed blobs that have been seen previously in gravitationally microlensing structuring of matter in quasar micro-lensing experiments (Schild, 1996; Schild & Vakulik 2003, Schild &Gibson 2011, Nieuwenhuizen Schild & Gibson 2011, Vakulik et al, 2004, 2007).
Published radio observations of this radiation show a patterning of this polarization, and the purpose of this report has been to guide future observation to be made with the still-expanding capabilities of the Event Horizon Telescope (EHT; Johnson & Doleman et al, 2015). In section 5 we discuss the expected polarization signature for this modeling of the observed structure and details of its expected polarization signature.

There is, however, a seeming problem which remains. The report by Lau et al 2013) which contains the final scientific report of the SOFIA/FORCAST NASA mission shows that the program scientists cannot explain the 3-armed structure predicted from MECO theory Their careful work shows that the plane of the imaged and structured accretion disc is tilted 23 degrees to the line-of-sight to the solar vicinity. Since it is well accepted that the plane of the Milky Way Galaxy is not inclined to the solar vicinity line-of-sight, we must conclude that the accretion disc luminous inner edge which also appears to be the equatorial plane of the compact central object of SgrA* is tilted with respect to the plane of the Galaxy. As noted, other planes have been discovered which might have an important relationship to the observed accretion disc inner edge ring. These already discovered planes include the plane of the Sagittatius infall stream (Kroupa et al, 2005, Metz et al, 2007), and the polar stream discovered in sub-mm emission with the sub-mm array (SMA). If future inter-comparison of these structures shows them all to be co-planer then we have a new perspective on the dynamics of supermassive MECO objects and their evolution.

It is well known statistically that few quasars are found in the local Universe (ie, $z < 0.5$). At lower redshifts, Seyfert galaxies are seen in abundance though they seem not to be as homogeneous a population as quasars, with Type 2, Type 1, type 1.4, etc commonly recognized. We speculate that quasar history includes 2 separate time scales. The first and best known is the commonly understood lifetime extending over redshift history 6 < quasar lifetime > 0.5). In our Galaxy we seem to be observing a process of local group dwarf spheroidal galaxy infall onto the Pole of our Galaxy and observed as suggested above. We speculate that in our own Galaxy and possibly typically others, such infall has established a non-equatorial inflow and accretion disc structure which has approached our central compact object and flipped its spin, so that the object seen today as SgrA* and its accretion disc are aligned today with the plane of infall, but mis-aligned with the Milky Way Galaxy's fundamental plane. The commonly known disappearance of classical quasars and the increasing detections of Seyfert Galaxies at low redshift seem to imply that this process is common today, so this has a separate time scale than seen in quasar studies.

Acknowledgement. I wish to thank Dr. Stanly Robertson for his up-to-date discussions of the MECO model, particularly the relationship of galactic scale to stellar scale objects.

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