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Galactic Clusters Stymied Rotating Space to Produce Ultra-Diffuse Galaxies

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Abstract Ultra-diffuse galaxies (UDGs) are unique to galactic clusters. They demonstrate a mechanism (rotating galactic space), which first by its absence and later by its development, simply and completely describes all phases of their formation and development within clusters. Galactic spatial rotation normally enables galactic gravity to hold high–speed stars in stable orbits within their local rotating space (without dark matter). UDGs developed in galactic clusters or other galactic groups where their orbits, through space, stymied early development of galactic spatial rotation, in some galaxies. This stymied rotation prevented its use, by pre-UDGs, to enable gravitational capture of their primordial stars and gases. And these stars and gases subsequently spiraled away, from impacted galaxies, in a whirlwind of high-speed mass. This whirlwind eventually pulled space into fast and broad rotation behind it. And this fast, new rotation not only enabled stable orbits (within local rotating space) for the small fraction of fast remaining stars, but also contributed extra speed to their orbits. These ultra diffuse, fast stars comprise recently discovered, UDGs. And some of the stars and gases, that the UDGs lost, eventually join into rich populations of globular clusters, which surround UDGs.

Keywords: *Ultra-diffuse galaxies, space, rotating space, galaxies, dark matter, galactic clusters, Coma*

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1. Introduction

UDGs are large, diffuse, spheroidal structures that contain only ~1 % of the stars present in ordinary galaxies [1]. Their origin and development are currently unsettled. Their stars are mostly red, which indicates very old age [2]. UDGs were recently discovered as a common component of galactic clusters by use of the Dragonfly telescope [1]. This telescope uses aligned, multiple, small telescopes to distinguish real faint images from reflected “ghosts” (in larger telescopes). By use of Dragonfly, astronomers estimate that there may be nearly as many UDGs (many as large as the Milky Way) as conventional galaxies in the Coma cluster [2]. This abundance of UDGs in Coma suggests that cluster dynamics played an important role in their formation, and that UDGs likely began their development as typical galaxies, which strayed early onto a different developmental path. These UDGs consist of diffuse, fast-moving stars, whose stable, fast orbit speeds are currently attributed to massive amounts of dark matter -- 98% of Dragonfly 44’s total mass, ~10^{12} solar mass [1]. Dragonfly 44 is a large UDG within the Coma complex.

The important role of cluster dynamics in UDGs’ formation, suggests that UDGs began their existence as proto galaxies, which were much like those that eventually developed into typical galaxies. One scenario, that describes the origins of both proto galaxies’ fast stellar, galactic orbits and their (initial) high ratios of orbiting mass to central mass, is that super massive black holes (SMBHs) appeared early in universal development [3]. These SMBHs moved toward galaxy-building, when they developed an accretion disk. In these disks, rapid early universal inflation acted with high-speed mass to shift accretion trajectories to fast galactic orbits. At this point UDGs and typical galaxies were similar, but their developments diverged shortly thereafter: The fast new stellar and gaseous orbits in typical galaxies drew space to follow them around the developing galaxies. And this rotating space reduced local orbit speeds and enabled stable galactic orbits, which were constrained by only the gravity from visible galactic components [4].

Pre-UDGs were less fortunate: Their fast galactic orbits through galactic cluster space (in some cases) stymied development of their spatial rotation, and they began to shed most of their fast moving stars and gases. Their currently observed, mostly old, red, first generation stars imply early galactic shedding, because their stars seem to have developed in an environment already depleted of the gas densities typical for normal star formation.

This Note describes the consequences of stymied early rotating space during a critical period of galactic development to begin UDGs’ differentiation from typical galaxies. This rotating-space theory simply describes how UDGs lost most of their primordial stars, and then stabilized a few remaining stars within newly acquired rotating space, which had been pulled into motion by the bulk of their stars and gases, as they spiraled away from their parent UDG. These lost stars and gases contributed to the abundant globular clusters around most UDGs. UDGs occur when imminently affected proto-galaxies move rapidly through space so as to discourage, early galactic spatial rotation. These recently discovered, UDGs are common within galactic clusters, and also occur among some smaller galactic gatherings [1]. Proto-galaxies, whose rotation axes are nearer perpendicular to their local galactic cluster orbit, are most vulnerable to stymied early spatial rotation. Note that cluster space also rotates to enable fast, stable galactic orbits within their clusters. However, galactic speeds, within local cluster space, remain sufficient to disrupt significant, early galactic spatial rotation in vulnerable galaxies. Thus, impacted galaxies cannot hold their stars to stable orbits (as do typical galaxies), and they begin to shed them into extra-galactic space. The shedding process spiraled billions of high-speed stars and gases away from their parent galaxies, to then induce broad and fast spatial rotation and to defeat the existing cluster-orbit restrictions, which had previously stymied UDGs' spatial rotation. This new, fast spatial rotation enabled the few remaining UDG stars to gain speed as they fell back into their UDGs, and it latter stabilized them in unusually fast galactic orbits.

2. Evidence for Rotating Space as the Enabler of Fast, Stellar Galactic Orbits

The rotating space mechanism explains stable galactic orbits. This mechanism asserts that galactic space rotates to follow fast-moving stars, and that fast-moving stars within this rotating space respond by interacting as with slower local orbit speeds, which enables visible-mass gravity to hold these fast stars in stable orbits, despite their continuing, observed high speeds. This theory employs galactic stars to drive the rotating space, so that each galaxy arrives at its own unique steady state. It does not require large-scale acquisition of external dark matter, which must assemble itself into a unique "halo" about a galaxy of ~1/6th its mass.

There are several examples of ways rotating galactic space simply enables and explains fast stellar orbits, and other unanticipated galactic structures:

1. Stellar orbit speed profiles conform to anticipated behavior from rotating space [4]. These orbit speeds, which reflect spatial rotation speeds, rise steadily from galactic centers to a transition point, at ~12K light years, where their rotation speeds become constant to the galaxies' edges. This behavior is consistent with galactic space rotating as it seeks to follow fast, abundant driver stars within the galactic bulge. Central galactic space does not rotate due to interference from nearby space. Then spatial rotation speeds rise steadily with increasing radius, in pursuit of fast moving space in the vicinity of its driver stars. At a transition point, these driver stars lose their capacity to pull space to move faster, due to resistance from extra-galactic space. Spatial rotation speeds at the transition point are then transmitted, at constant tangential speed, to outer galactic regions, from the moving galactic space interior to it. Outer-region, "constant" orbit speeds are surprisingly similar between large and small galaxies. This observation suggests that they are not primarily a size-related phenomenon, but rather resulted from a more size-independent effect, such as resistance from extra galactic space, to regulate their plateau speeds.
2. Bars and sharp transitions to spirals in spiral galaxies also conform well to a rotating space mechanism [5]. Linear spatial rotation speed increases (out to a transition point) enable formation of stable linear bars of stars, which are common at the centers of spiral galaxies. Also, their relatively sharp transitions from bars to graceful spirals are well explained as sharp transitions from linearly increasing interior spatial speed, to constant outer-galactic rotation speed. Finally, the graceful spirals themselves require constant-speed tangential spatial rotation speeds, which develop naturally within the rotating space proposal. All three of these phenomena would require very unique distributions of dark matter in order to project the required gravities for their formation, while also overcoming the inverse-squared distance functionalities normally associated with gravity-based interactions.
3. The simple and complete description of UDGs by application of rotating space concepts to them, in this letter, also supports this mechanism.

3. Mechanism of Stymied UDGs' Spatial Rotation

Cluster galaxies move, within rotating local cluster space, at speeds, which are sufficient to maintain stable orbits within the local cluster. And this speed through local cluster space (outside observer speed less cluster space rotation speed) is nonetheless sufficient to disrupt early spatial rotation within almost half of proto-galaxies of the cluster. These proto-galaxies were compact and their stars and gases orbited about their central, super massive black hole at near accretion disk speeds. The space encompassing these galaxies would normally have begun rotating to follow their high-speed stars and gases. However, galaxies, with rotation axies parallel with the cluster axis, move edge-on through galactic cluster space. Here, leading-edge galactic space, that began to rotate, was swept by UDGs' movement through cluster space into the trailing galactic section, where it interfered directly with trailing edge space, to prevent continued speed increase of that galaxy's rotating space. Typical galaxy development depended on this rotating galactic space to enable stable stellar orbits, held by the respective galaxies' observable mass. When this spatial rotation was stymied, the impacted galaxies could not hold most of their stars in stable orbits; and they spiraled away from parent galaxies in a process that eventually removed (or prevented acquisition of) ~99% of their primordial stars. Galaxies, whose rotational axies were parallel to the cluster axis, were most vulnerable to stymied spatial rotation, because of their continuous edge-on movement through cluster space.

In contrast, galaxies, with off-parallel alignment with the cluster axis, would see only periodic and tilted, edge-on movement through cluster space, during 2 quarters of their orbits. This periodic edge-on encounter with cluster space was insufficient to disrupt establishment of rotating space in non-aligned galaxies. And shifts of rotating space toward the trailing side of an orbiting galaxy did not significantly interfere with its development. Current estimates that UDGs (in clusters) may number close to their normal sisters, suggests that (with random proto galaxy orientation) a declination angle (from Coma axis) approaching 6o degrees may have represented the approximate dividing line between UDG and normal-galaxy development. Their commonality also suggests that UDGs began their existence as typical galaxies, but that their presence within a cluster interfered with their continued normal development.

4. Mechanism for Later Acquisition of Spatial Rotation by UDGs

Stymied early acquisition of spatial rotation, in some cluster galaxies, prevented establishment of stable stellar orbits, and this instability led to massive galactic shedding of high-speed stars and gases. This shedding left affected galaxies in extended, temporary fields of very high-speed, rotating stars and gases. These fields had sufficient size, speed and mass to defeat the still-existing, rotation-stopping mechanism, which had resulted from UDGs' movement through cluster space. And thus, during shedding, the space in and around developing UDGs began to follow and rotate with their escaping, very high-speed, and wide-ranging stars and gases as they spiraled away from their parent galaxies. Although this space could not capture and stabilize most escaping stars and gases, it did acquire more speed and size than rotating space would normally have attained as it followed the stars about typical galaxies.

Stars and gases, that were lost during the shedding process, explain the rich fields of globular clusters surrounding UDGs. These shedded stars would have lost much of their orbital speed during their escape from their UDG source, and they could thus easily associate into globular clusters, around their UDGs. Globular clusters also represent a distance, at which the rotating space, left by shedded stars and gases, lost significant influence. A few slower, interior stars would have been captured by the UDGs' rotating space and fallen back toward their parent UDGs to establish stable orbits. Thus the collective mass in these globular clusters represents the "last" fraction of stars to leave their respective UDGs. And the separation point between last-to-escape and destine-for-capture stars would show: not only the limits of rotating space impact, but also how far some of the captured stars had fallen to find stable UDG orbits. The earlest escaped mass scattered deeper into space and contained larger portions of gas and unlit pre-stars.

Rapidly rotating space, left by escaping stars, not only stabilized a few remaining, escape-velocity stars into fast, stable, wide-ranging UDG orbits; but it also contributed to their extra speed. Thus, fast UDG stellar orbits, stabilized by newly rotating space, eliminated the requirement for massive amounts of dark matter. And conversely, these diffuse, fast-moving stars now help to maintain that rotating space (though they could not have initiated it by themselves).

5. Mechanism of UDGs' Extra Orbit Speed

UDGs show stellar orbit speeds beyond those of typical galaxies. These stars gained some of their extra, high-speed orbit, energy, as they fell back toward their parent galaxies, once rotating space established itself. This rotation lowered the local orbit speeds of escaping stars (without changing their speed to an outside observer); and this lowered local speed caused the last of the escaping stars to spiral back toward their galactic centers – thereby gaining extra orbit speed (both to an outside observer and within their local space). Considering the mass of stars captured by UDGs, the star-capturing process likely followed most of the stellar shedding, after rotating space had established and begun to assert itself. Captured stars increased their orbit speeds by continuing their fall back through local space toward UDGs' centers until their local-space orbit speeds increased enough to stabilize their orbits. Note that local stellar orbit speeds rise due to both the stars' fall toward UDGs' centers and from decreased spatial rotation speeds closer to UDGs' centers.

UDGs spatial rotation speed profiles should differ from those of typical galaxies: Typical galaxies' spatial rotation speeds increase linearly out to a transition point where they become constant and hold that speed out beyond the galaxies' edge. UDGs' rotating space develops later in galaxy development, as it moved to follow fast, wide-ranging stars and gases within and beyond normal galactic limits during their spiral away from parent UDGs. Thus UDGs' space rotates faster and over a much broader region than typical galactic space. Given that UDGs' driver stars were at or beyond typical galactic limits, UDGs' spatial speed profiles should increase linearly out to distances of maximum driver star influence. And thus, UDGs' stellar orbit speeds should reflect these linear spatial speed increases through their entire galaxies.

In-spiraling, captured UDG stars quickly arrive at stable orbits, with spatial rotation speeds decreasing linearly with decreasing orbit radius, while their "observed" speeds gravitationally increased. This feature helps to explain the large size of many UDGs, despite their dearth of stars. Speed within local space determines a star's centrifugal force. Again, local stellar speeds increase with stellar movement toward UDGs' centers due to both decreased spatial rotation speeds, and gravity-induced increased stellar speeds.

6. UDGs' Spheroid Shape

UDGs' spheroid shape traces back to their unique development: Their broad and deep expanse of rotating space, which derived from billions of escaping stars and gases, enables their thicker spheroid shape. And the out-of-plane elements in the escape paths of eventually-recaptured stars assures that returning stars will have significant out-of-plane components to their orbits as well. Even if UDGs' proto galaxies were typically thin disks, their escaping stars likely spiraled off with any out-of plane component that would aid in their escape from the proto galactic disk. As these stars and gases spiraled away from their parent "galaxies", they occupied thicker space than do galactic disks, and thus pulled space with them into deep, broad rotating disks, that occupied much greater volumes than the rotating space about typical galaxies. These large disks of rotating space about UDGs enabled them to capture and accommodate the far-flung orbits of stars recaptured by their newly-acquired rotating space. UDGs' continuing spheroid shape attests to the diffuse nature of UDGs' stars, which exert little gravitational pull to draw the scattered stars back toward a thinner disk.

7. Tests of Rotating Space from UDG Observations

Observational tests of rotating space as the enabler of stable UDG orbits may be available:

1. Do normal-galaxy orientations, in Coma, indicate selective loss of galaxies, with declination angles of up to ~60 degrees, from the Coma cluster axis? Galaxies maintain their orientations through time. And galaxies with near-parallel axies were most vulnerable to stymied development of rotating space. These galaxies continually moved through Coma space at edge-on angles to their galactic planes. And galaxies, with significant, off-parallel orientations, at most experience edge-on movement during parts of only 2 quarters of their orbits.
2. Do stellar orbit speeds increase linearly from UDG centers out to their edges? Linear spatial speed increases occur where driver stars of rotating space lie beyond the interior galactic space being considered. These linear speed increases enable stable bar formation from the centers of barred, spiral galaxies out to a transition point where driver stars can no longer pull galactic space to rotate faster and spatial rotation speed becomes constant [5]. The driver stars for UDGs were billions of escaping stars – well beyond the current edges of UDG galaxies. Thus the speed of rotating UDG space should continue to increase linearly out beyond UDGs' visible limits, and this linearity should be reflected galactic stellar orbit speeds. Dark matter would require unique distributions to generate linear stellar speed increases. Gravity-driven fields generally show some inverse-squared functionality.

8. Discussion

The association of dark UDGs with galactic clusters is a consequence of the distinguishing factor between cluster galaxies and non-associated galaxies: cluster galaxies move in rapid orbits through space while non-associated galaxies develop in more quiescent space, with slower movement through it.

The above Note describes how rapid movement through space (by galaxies with axies somewhat parallel to the cluster axis) stymied early development of rotating space. This rotating space was essential to establish stable, high-speed stellar orbits in conventional, non-associated galaxies (and ~half of cluster galaxies). Thus UDGs demonstrate (by its absence) the star-shedding consequences of stymied early rotating space for typical galactic development. Later, billions of escaping stars and gases pulled local galactic space to follow their rotation to faster speeds and over broader regions than did rotating space in typical galaxies; and the few remaining fast, escape-velocity stars were sped up and later orbit-stabilized by this high-speed, galactic spatial rotation – an enduring remnant of previously shedded stars. Rotating space also raised orbit speeds of remaining UDG stars as it reduced their local orbit speeds to let them "fall" into faster and lower stable orbits. Current theory requires enormous masses of "dark matter" halos to contain UDGs' fast stellar orbits. And this dark matter presents a two pronged dilemma: if it was present during early stages of UDGs' development, how did they lose 99% of their stars with all of this dark matter to hold them in place, or where did all of this dark matter come from after the galaxies lost most of their stars? The general consistency in UDG appearance implies that they experienced a similar set of circumstances leading up to their current state. Massive and consistent infusions of dark matter seem unlikely across this broad population of UDGs. On the other hand, the rotating space scenario simply and completely describes UDGs' early loss of most of their mass, and the stabilized fast orbits of their few remaining stars. Here, early stymied spatial rotation prevented normal development of stable, high-speed stellar orbits for ~99% of their stars; and as these stars spiraled away from their parent galaxy, they pulled space to move fast enough to capture the remaining ~1% of high-speed stars in stable orbits within these ultra-diffuse galaxies. The simplicity and completeness of the rotating space proposal for UDGs, adds to a compelling case for its displacement of dark matter as the mechanism of orbit stabilization within galaxies.

List of Abbreviations

SMBHs	Super Massive Black Holes
UDGs	Ultra-Diffuse Galaxies.

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