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Those MOJAVE Samples That Are Sufficient to Change the Research Direction of Quasars

—I. Samples of Morphological Abnormalities Caused by "Jets within Jet"

Yunbiao Yang

Shanghai DiGi-Graphic Information System Ltd., Shanghai, China
Email: yybiao@hotmail.com

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Abstract

There are many quasar samples with abnormal morphologies in the database of the MOJAVE website. The evolutionary forms of these samples are vastly different from the explanatory schemes (or models) described in existing theoretical frameworks. Among them, the relevant research articles on some samples (such as 0509+406) are few and far between, which indicates that under the current theoretical conditions, researchers are reluctant to be involved in these abnormal samples. However, the overall correlation of the quasar anomalies has been ignored. This might be an important reason why quasars, despite over 60 years of efforts since their discovery and research, have yet to make substantial progress. For the quasar samples 0509+406 and 2351+456 (4C45.51, z = 1.986), diffuse distribution knots occurred in the transverse direction of the jet axis. It seems difficult to explain this scene using the current popular research framework (SMBH+RBM, Supermassive Black Holes and Relativistic Beaming Model). The superluminal motion that occurred in 4C39.25 (z = 0.697) was not caused by the core component but by the jet knot (that is, the so-called "jets within jet" phenomenon), and remains unresolved at present. This paper attempts to illustrate that there is a correlation between the diffuse distribution knots in the transverse direction of the jet axis and the phenomenon of "jets within jet". As for Quasar 4C39.25, its reasonable real picture may have been completely divorced from the existing theoretical framework.

Keywords

Origin of Jet Knots, Jets within Jet, Diffused/Distributed Knots in Transverse of Jet Axis, MOJAVE Samples

1. Introduction

More than 60 years after the discovery of quasars, our research results may still be far from the truth. Several major mysteries related to quasars remain unresolved. One notable example is Quasar 4C39.25. This abnormal sample has transformed from a subluminal source to a superluminal source. The superluminal motion pattern demonstrated has not yet received a reasonable and recognized explanation. In the motion mode of 4C39.25, the ejection of the superluminal component is not the usual radio core, but the jet knot! This superluminal motion mode is vastly different from the existing SMBH+RBM framework. At present, few studies have been conducted in-depth research and reviews of this phenomenon. 0814+425 (z = 0.245) and 0938-076 (z = 1.724) are two other MOJAVE samples similar to this one. In fact, the jet phenomenon within the jets is ubiquitous throughout the entire quasar sample library. It is found in the available literature that 3C159 (z = 0.482), PKS1421-490 (z = 0.669), 3C215 (z = 0.411), 3C249.1 (z = 0.311) and 3C277.3 (z = 0.085), etc., are all typical samples of the "jet within the jet" phenomenon. This indicates that in the world of quasars, the phenomenon of jet within jets (or secondary jets) occurs very easily. This is far from the strict conditions of the currently popular Kerr rotating black hole model that generates bipolar jets, and also means that various abnormal behaviors of quasars break away from the effective constraints of our existing theoretical research framework. Significant differences between the explanatory models based on existing theories and the observed facts have been addressed in some studies [1]-[3]. At present, owing to the strong limitations of the existing theories on the emergence of new physical perspectives, this difference is difficult to change. Fortunately, a large number of evolutionary videos of quasar samples have been on the MOJAVE website. Although these videos are composed of frames of sample morphology images from different epochs, there is no doubt about the authenticity and validity of quasar evolution scenarios. Therefore, if the overall correlation of quasar anomalies is taken as an effective theoretical standard for research on the basis of respecting observational facts, the situation might undergo a qualitative change to promote the emergence of reasonable new physical perspectives.

2. The Origin Issue of Jet Knots

The view that jet knots are formed by the interaction between the jet material and interstellar medium (or the dust of the host galaxy) is widely accepted in the current related research field. However, in many samples of MOJAVE, the picture presented by the evolutionary process of the outflow of nuclear matter from quasars is not like this. **Figure 1** shows three frames of MOJAVE sample 2243-123 (z = 0.632), representing its evolutionary states at three epochs in 1997, 2003, and 2007. It can be clearly seen that the bright knots closest to the core are entirely formed by the outflow and aggregation of core material. In the northeast direction of 2243-123, there is a clump that was previously separated from the core region and appears as a relatively faint knot. Thus, the popular view on the formation of jet knots mentioned above is unconvincing. Quasar 0938-076 (z = 1.724) is another sample that does not conform to the "currently popular scenario of jet knot formation". As shown in Figure 2, the bright knots in the downstream region consist of materials that originate directly from the upstream knots and the material separated from the core. Because of the unusual radio morphology exhibited by 0938-076, the author of this paper has not found any research articles on it in the existing literature. This indicates that this sample is so abrupt and abnormal in the SMBH+RBM research framework.

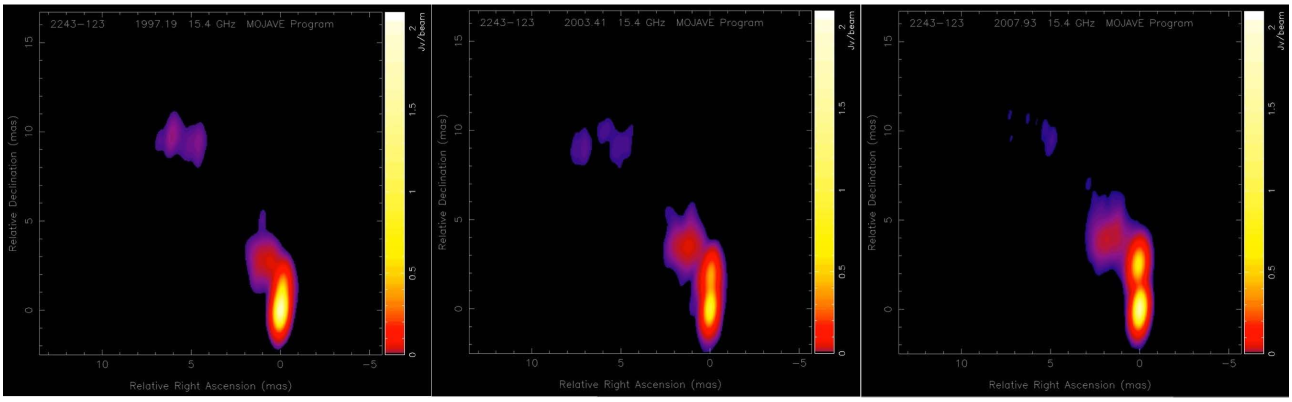

Figure 1. Pictures from the evolution video of MOJAVE sample 2243-123.

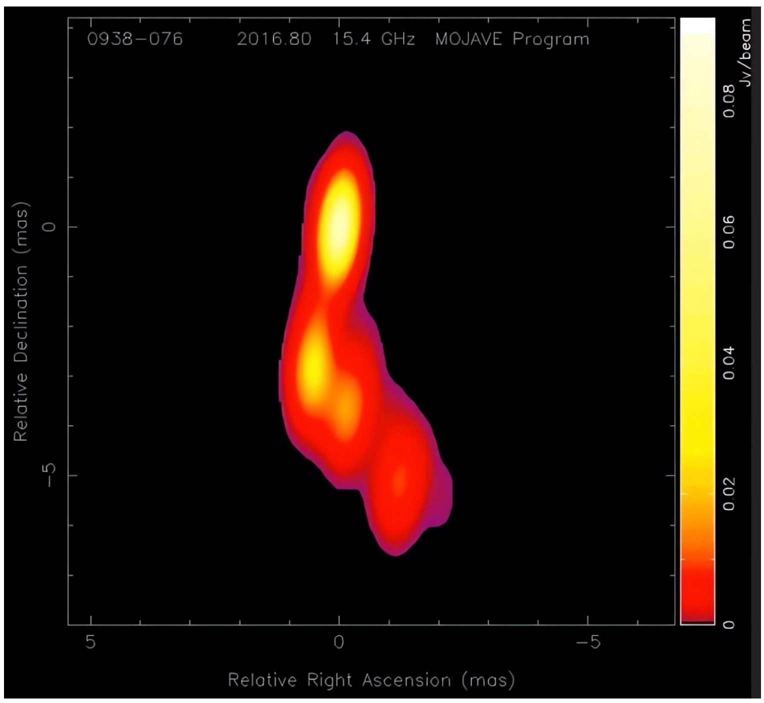

Figure 2. Picture from MOJAVE sample 0938-076.

3. The Phenomenon of "Jets within Jet"

The term "jets within jet" is rare in the existing literature. It was used by Ackermann *et al.* (2014) in an article on the peculiar quasar 3C+21.35 (z = 0.432) [4].

The MOJAVE website provides a sample of jets with anomalous morphology. Around 2010, the evolution video showed that the material separated from the core region, moving due north, followed a distorted trajectory (cf. right of Figure 3) and formed a slowly moving knot approximately 8mas away from the core (cf. left of Figure 3). This is the source of background data described in Ackermann's article.

In the last two decades of the last century, there were a large number of research articles on Quasar 4C39.25, making it the focus of research in this field. It is worthwhile to review the historical process related to research on 4C39.25, because the mysteries surrounding 4C39.25 have not yet dissipated to this day.

The article published by Shaffer *et al.* in 1977 indicates [5] that 4C39.25 is a subluminal radio source, which consists of two relatively stationary bright spots, one in the east and the other in the west (cf. Figure 4(a) & Figure 4(b)). Since 1982, a superluminal (approximately 3.8c) component ***b*** has separated from the western bright spot (component ***c***) (cf. Figure 4(d)) and moved toward the eastern bright spot (component ***a***) (see Figure 4(g)). Thus, the article by Shaffer *et al.* (1987) [6] has already described and studied 4C39.25 as a superluminal radio source. They pointed out the unusual aspects of the superluminal motion pattern of this radio source. The article cited the view in the article by Marscher *et al.* (1987) [7], that it is not the core component that causes superluminal motion, but a relatively stationary jet knot. Marcaide *et al.* (1990) [8] confirmed in their article that there is a faint flat spectrum component on the western side of component ***c***, which has been identified as the core component ***d*** of 4C39.25 (cf. Figure 5). Secondly, Shaffer's article points out: "*rather than being one of the prime examples of a subluminal source*, 4*C* 39.25 *contains both superluminal and subluminal components*."

Non-core components trigger superluminal motion, and this motion pattern

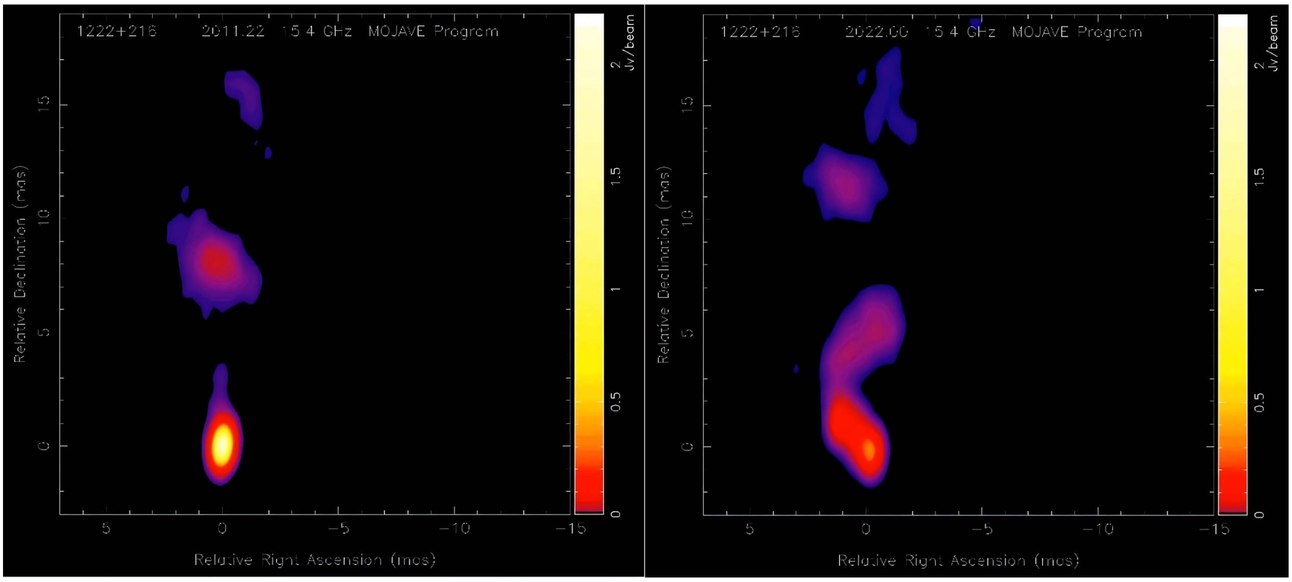

Figure 3. Pictures from MOJAVE sample 1222+216.

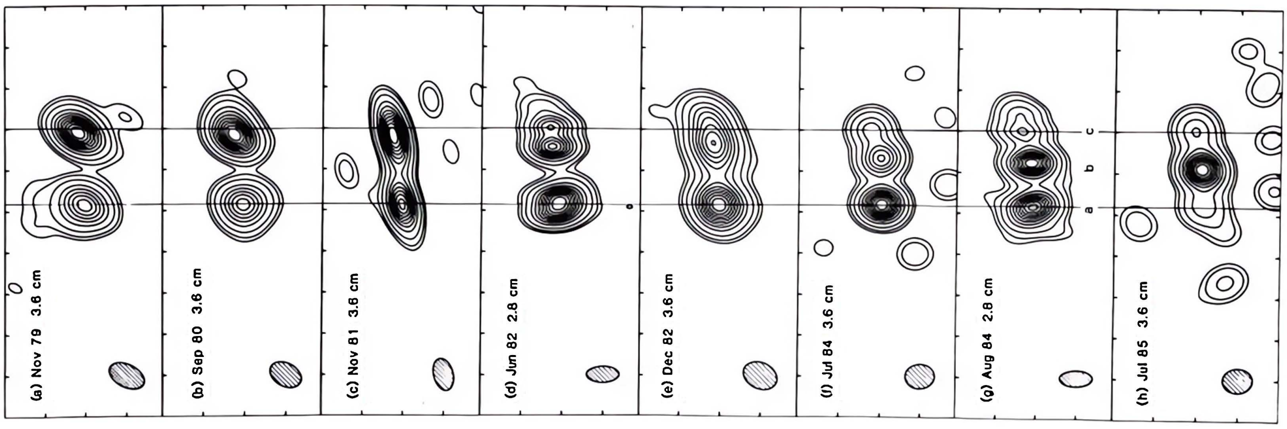

Figure 4. VLBI maps of 4C 39.25 at the given wavelengths and epochs [6].

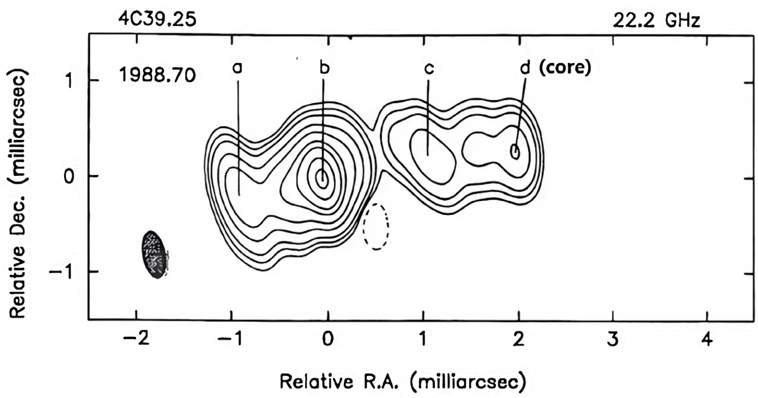

Figure 5. Map of the quasar 4C 39.25 at 22 GHz in 1988 [13].

has had a significant impact on the research framework of SMBH+RBM. Therefore, Marscher *et al.* (1991) [9] pointed out in their article: "*Any successful model for* 4*C*39.25 *that seeks to explain this source using the standard relativistic jet model for core-jet sources* (*Blandford & Konigl* 1981; *Marscher* 1980) *must account for the appearance of two stationary features downstream from the core* [cf. above section]", [9] Hereto, the question boils down to: why do these two stationary knots form and what is the physical mechanism behind them? Several studies have constructed explanatory models for this complex problem. In the article by Shaffer *et al.* (1987), four possible scenarios were described as explanatory models for 4C39.25. In the article by Marcaide *et al.* (1989) [10], the stationarity of components ***a*** and ***c*** in 4C39.25 is attributed to their trajectories curving toward the observer's line of sight. Since then, in the 4C39.25 special review articles published by Alberdi *et al.* in 1993 [11] and 2000 [12], this explanatory model has been adopted for both the stationary ***a*** and ***c*** components. In the article by Alberdi *et al.* (2000) [12], in order to achieve the rationality of the model, strict restrictions were imposed on the observer's perspective: "*We interpret the stationary feature as a bend in the jet trajectory in a plane that does not contain the observer, and the moving one as a shock turning around the bend.*" Setting aside whether this scenario is physically plausible, there is already a logical inconsistency from a physics perspective: In the RBM interpreting solution, the faster the jet material moves at superluminal speeds, the smaller the viewing angle becomes—meaning it appears closer to the line of sight. Meanwhile, in the stationary knot interpretation proposed by Marcaide *et al.*, even a decelerating jet bends toward the observer's line of sight. From this, the paradox emerges that both accelerated and decelerated motion within the jet will bend toward the line of sight.

The anomalies that occurred in 4C39.25 are not limited to this. As shown in Figure 4, when component ***b*** separates from component ***c*** and moves toward component ***a***, both ***a*** and ***b*** become brighter when ***b*** approaches component ***a***. Alberdi *et al.* (2000) [12] described that when component ***b*** moves to component ***a***, it decelerates and then moves around component ***a***. The article only mentions that these observational results are evidence of the interaction between component *b* and component ***a***, and does not elaborate on the physical mechanism that generates these behaviors.

Another anomaly of 4C39.25 seems to have been seriously ignored. In Figure 6, the brightness of the jet knot and radio core are almost reversed. In the research framework of SMBH+RBM, the high-energy and bright characteristics of quasar nuclei are in line with the status of SMBH as an energy center, whereas the morphology displayed by 4C39.25 is far from the standard model. The phenomenon where the brightness of the jet knots exceeds that of the radio core is not an isolated case in the quasar world but rather a common existence. 3C48 [14], OQ208 [15], and numerous weak-core or coreless CSO sources [16] are excellent examples of this morphology. Even FRII-type radio sources appear to be a continuation of this anomaly. Therefore, the underlying mechanism behind this anomalous phenomenon is the fundamental reason why observational facts gradually diverge from existing theoretical frameworks.

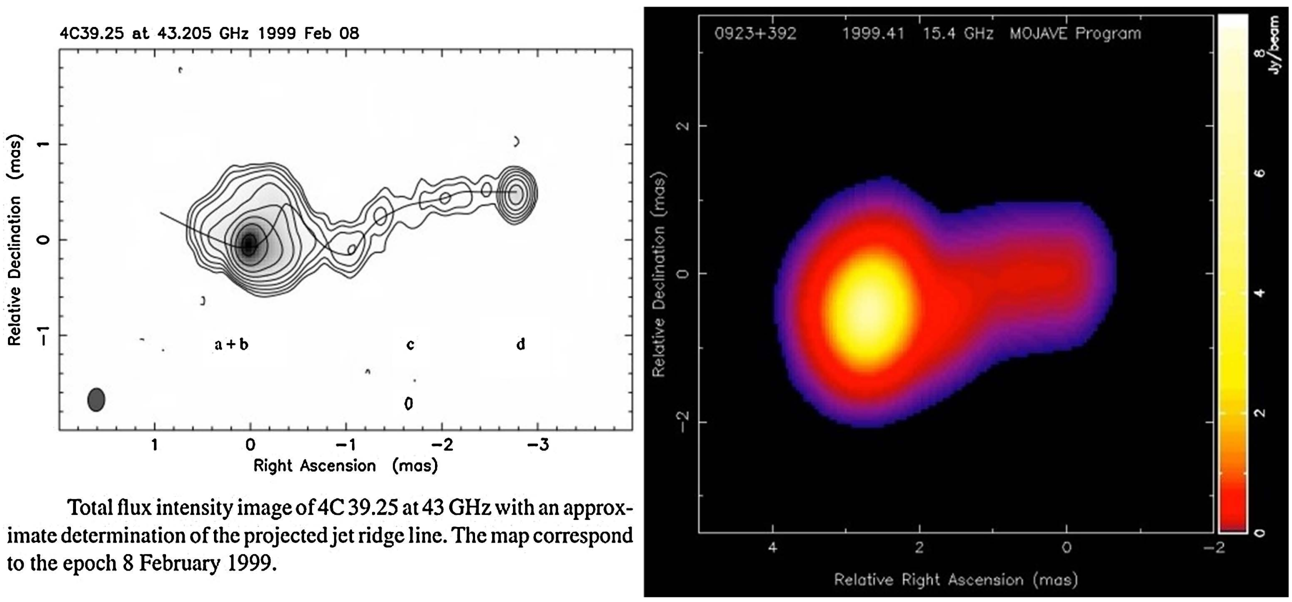

Figure 6. Left from Alberdi *et al.* (2000) [12], right from MOJAVE website.

4. The Diffused Distribution Knots Appearing in the Transverse Direction of the Jet Axis

The most striking sample in this short article was the 0509+406. Although the redshift value of this sample has not been found in the searchable databases, the JOJAVE website still provides an extremely valuable evolution video (refer to Figure 7 two frame images are from 2014 and 2021). In the special topic literature on a vast number of quasar samples, no research articles on 0509+406 were found. Under such circumstances, perhaps it can be understood as a sample of peculiar quasars that no one wants to touch.

According to normal physical logic, particles in the direction of the jet axis usually have a high energy, whereas diffuse particles in the transverse direction of the jet axis have a low energy. However, in the radio morphology map of 0509+406, the diffuse material in the transverse direction of the jet axis is surprisingly distributed in clumpy formations. This is a scenario that the existing quasar research framework based on the theory of gravity (SMBH+RBM) does not wish to see. The knot (or clumpy material) that appears in the jet currently the popular view is the shock model theory, that is, it is formed by the interaction between high-energy jet matter and the interstellar medium. Therefore, the existence of the 0509+406 sample makes the shock model constructed by the SMBH+RBM theory pale and weak. The sample with a similar to 0509+406 was 2351+456 (z = 1.986), refer to left of Figure 8. In the one-sided jet from east to west at 2351+456, the jet axis is not a straight line. Diffuse distribution knots also occur laterally along the jet axis. In the evolution video of 2351+456, the process of radio nuclear separation can be observed (see right of Figure 8).

From the aforementioned phenomena observed in 4C39.25—namely, the transfer of energy from a faint core to a compact, high-luminosity knot, interaction

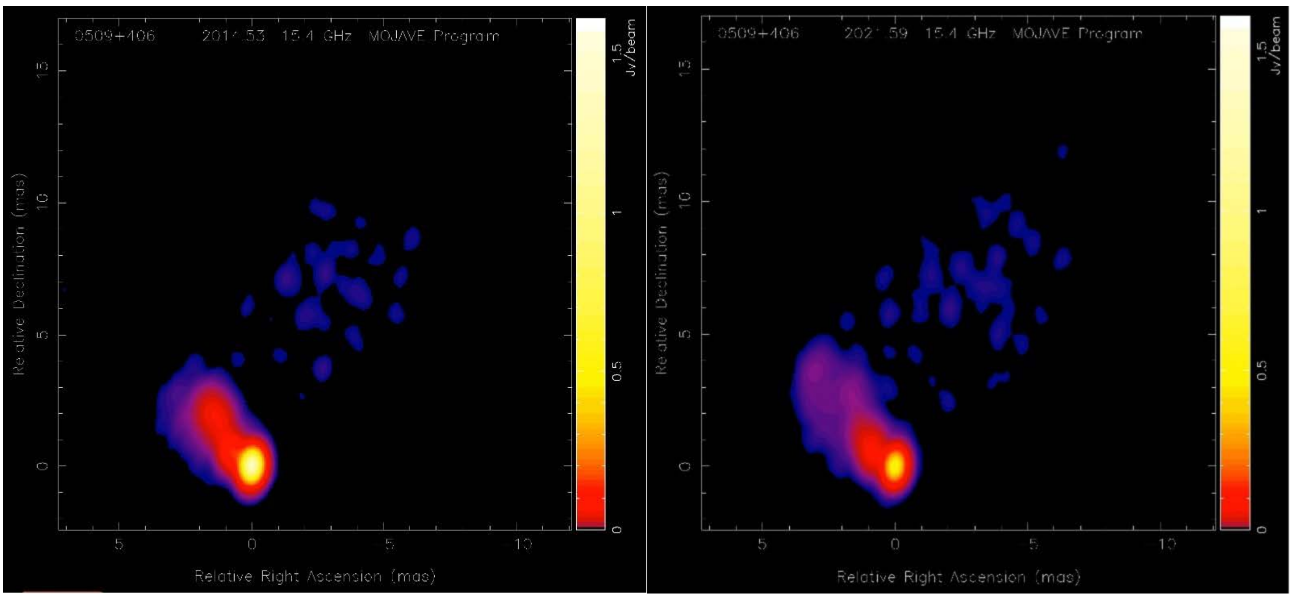

Figure 7. Maps from MOJAVE website.

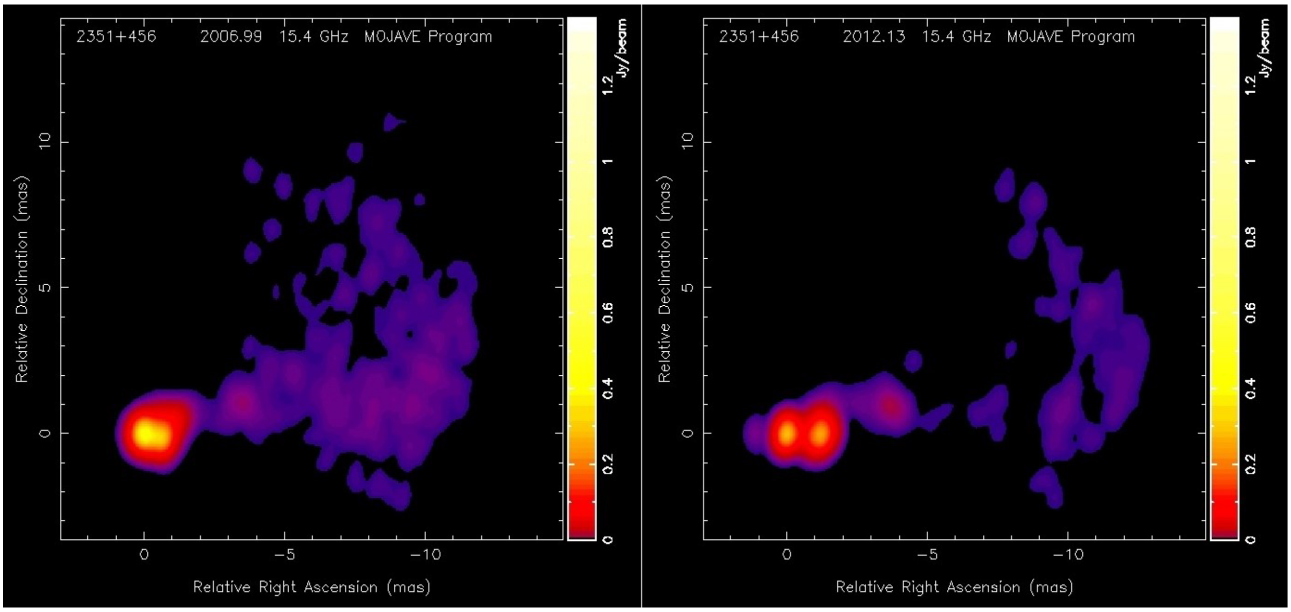

Figure 8. Maps from MOJAVE website.

behavior between superluminal motion knots and nearly stationary high-luminosity knots, and the core structure separation observed in the 2351+456 sample, it can be inferred that the transversely distributed knots along the jet axis in the 0509+406 sample represent the self-condensation behavior of a particle system with unique properties that cannot be explained by gravity alone. Moreover, the self-condensation characteristics of this special particle system have already exceeded the boundaries of the existing theoretical frameworks.

5. Discussion

A simple theory exists that can integrate the anomalies of the aforementioned samples within a new theoretical framework. These anomalies were originally thought to be related as a whole. The anomalies of various phenomena of quasars, seemingly a challenge to the existing theoretical framework, are gifts prepared for the new theoretical framework. The overall correlation of quasar anomalies is manifested as mutual self-consistency within the framework of the new theory. This new physical framework can reasonably explain the strange superluminal motion mode occurring in 4C39.25, as well as the diffuse distribution knot in the transverse direction of the jets that emerged in Quasar 0509+406. On account of behind the abnormal behaviors of these two samples, there is the same physical logic. Almost all anomalies that occur in quasars point in one direction, namely, superluminal motion is real, while the stationary of the quasar nucleus and the stationary bright knots of jets are apparent only (high energy and approaching the speed of light).

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The research data and images in this article are mainly from the MOJAVE website.

MOJAVE Samples Database Link

https://www.cv.nrao.edu/MOJAVE/allsources.html.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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