

GÜNEŞ BENZERİ YILDIZLARDAKİ LEKE GRUPLARININ BOYLAMSAL ANALİZİ

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ÖZET

Bu çalışmada, Güneş benzeri sekiz yıldızın yüzeydeki aktif bölgelerinin boylamsal dağılımı ve zamansal evrimi incelenmiştir. Çalışmanın temel amacı, aktif bölgelerin kararlılığını, leke gruplarının oluşum ve sürüklenme davranışlarını karşılaştırmalı olarak araştırmak ve bu özellikleri yıldızların dönme karakteristikleri ile manyetik aktivite düzeyleri bağlamında değerlendirmektir. Bu kapsamda, Kepler ışık eğrilerinden elde edilen leke noktaları dönme periyotları kullanılarak boylamsal uzayına taşınmış, aktif bölgelerin uzaysal organizasyonunu DBSCAN tabanlı kümeleme analizi ile belirlemiş ve kümelemiş leke noktalarının toplam leke noktalarına oran olarak tanımlanan Nesting Degree (ND) ile nicel hale getirilmiştir. Böylece aktif bölgelerin yalnızca görsel olarak belirlenmesi yerine, leke öbeğlenmesinin çevrimler boyunca nasıl değiştiği, hangi yıldızlarda daha belirgin olduğu ve yıldızların dönme özellikleriyle nasıl ilişkilendiği sistematik olarak karşılaştırılmıştır. Elde edilen sonuçlar, yıldız lekelerinin yüzeyde tamamen rastgele dağıldığını; bazı yıldızlarda belirli boyllarlar çevresinde belirgin bir öbeğlenme eğilimi gösterdiğini ortaya koymaktadır. Çevrim-çevrim Nesting Degree analizi, bu organizasyonun zaman içinde sabit olmayabileceğini ve yıldızın yıldızda farklılık gösterebildiğini ortaya koyarken, leke çevrimi ve çevrim genişliği ile birlikte değerlendirildiğinde manyetik aktivitenin yalnızca miktarının değil, yıldızın manyetik aktivitesinin de önemli bir karakteristik olduğunu göstermektedir.

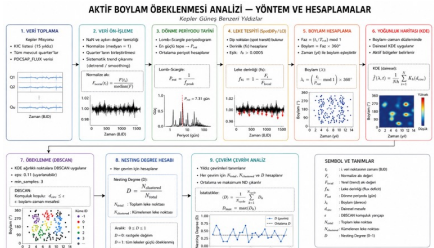
MOTİVASYON

Kepler'in yüksek hassasiyetli fotometrisi, yıldız lekelerinin evrimini ve manyetik aktiviteyi uzun zaman ölçeğinde incelemeyi mümkün kılar. Yıldız lekeleri, dönme ve manyetik aktivitenin yüzeydeki gözlenebilir izleyicileri olarak yıldız dinamosunun araştırılmasında temel bir araçtır. Leke dağılımlarının yalnızca aktivite genişliğiyle değil, boylam-zaman uzayındaki mekansal öbeğlenmeleriyle incelenmesi, yıldız manyetik alanlarının yüzey aktivitelevlerinin anlaşılmasına katkı sağlar.

Çalışmanın gelecek aşamasının bir örneği

YÖNTEM

Kepler uzay teleskobu tarafından gözlenen sekiz Güneş benzeri yıldızda ait hassas ve uzun zaman aralığına dağılımı fotometrik verileri kullanılmıştır. Işık eğrileri Python tabanlı analiz araçları ile işlenmiş, SpotDIPy yazılımı kullanılarak LCI (Light Curve Inversion) yöntemi ile yıldız yüzey haritaları elde edilmiştir. Geliştirilen bir iz sürme algoritması yardımıyla leke grupları otomatik olarak belirlenmiş, boylam-zaman haritaları üzerinden aktif bölgelerin evrimi, boylamsal sürüklenmeleri ve zamansal değişimleri nicel olarak analiz edilmiştir.



Yıldızın dönme periyodu P_{rot} , ışık eğrisindeki periyodik modülasyonlardan elde edilmektedir. Kodda bunun için Lomb-Scargle periyodogramı kullanıldı. Çalışmanın temel gözlemsel girişi, ışık eğrisindeki karanlık yıldız lekelerine karşılık gelen alı düşüşleridir. Öncelikle normalize edilmiş ışık eğrisinden uzun dönemli dönem çıkarılmaktadır. f'siy doğrudan "yıldız yüzeyinin gerçek leke alanı" şeklinde ifade etmek yerine fotometrik leke derinliği olarak tanımlamak daha doğru olur. Dolayısıyla yöntem, doğrudan her fiziksel lekelerin geometrik alanını ölçmekten ziyade, ışık eğrisinde gözlenen fotometrik kararmayı leke göstergesi olarak kullanmaktadır. Boylam-zaman düzlemindeki leke noktalarının dağılımı yalnızca görsel olarak değerlendirilmemektedir, DBSCAN ile nicel olarak analiz edilmektedir.

YILDIZLARA AİT BİLGİLER

Güneş Benzeri Yıldızlar — Kepler Leke Analizi Sonuçları

KIC	Q	Toplam Leke Sayısı	Ortalama Dönme Periyodu (min)	(D)
7895206	18	13 135	51.06	0.931 ± 0.162
9468789	18	24 330	6.49	0.997 ± 0.009
6681913	18	22 040	9.08	0.991 ± 0.036
8009475	18	18 229	12.76	0.979 ± 0.134
8952206	17	262	20.14	0.979 ± 0.422
6351285	18	293	16.31	0.848 ± 0.316
7203835	18	13	16.66	1.000 ± 0.000
6507505	18	5 951	18.00	0.885 ± 0.198
8621906	18	24 354	5.45	0.996 ± 0.016
5865729	18	57	18.23	0.727 ± 0.422
6745430	18	26 934	4.49	0.990 ± 0.065
10975635	18	1 944	21.08	0.817 ± 0.281
7611798	18	5 290	13.32	0.913 ± 0.194
5773489	14	17 365	7.31	0.996 ± 0.015
7190814	17	9 285	9.09	0.935 ± 0.173

● Kepler Quarter 5/6/7/8/9/10/11/12/13/14/15/16/17/18/19/20/21/22/23/24/25/26/27/28/29/30/31/32/33/34/35/36/37/38/39/40/41/42/43/44/45/46/47/48/49/50/51/52/53/54/55/56/57/58/59/60/61/62/63/64/65/66/67/68/69/70/71/72/73/74/75/76/77/78/79/80/81/82/83/84/85/86/87/88/89/90/91/92/93/94/95/96/97/98/99/100/101/102/103/104/105/106/107/108/109/110/111/112/113/114/115/116/117/118/119/120/121/122/123/124/125/126/127/128/129/130/131/132/133/134/135/136/137/138/139/140/141/142/143/144/145/146/147/148/149/150/151/152/153/154/155/156/157/158/159/160/161/162/163/164/165/166/167/168/169/170/171/172/173/174/175/176/177/178/179/180/181/182/183/184/185/186/187/188/189/190/191/192/193/194/195/196/197/198/199/200/201/202/203/204/205/206/207/208/209/210/211/212/213/214/215/216/217/218/219/220/221/222/223/224/225/226/227/228/229/230/231/232/233/234/235/236/237/238/239/240/241/242/243/244/245/246/247/248/249/250/251/252/253/254/255/256/257/258/259/260/261/262/263/264/265/266/267/268/269/270/271/272/273/274/275/276/277/278/279/280/281/282/283/284/285/286/287/288/289/290/291/292/293/294/295/296/297/298/299/300/301/302/303/304/305/306/307/308/309/310/311/312/313/314/315/316/317/318/319/320/321/322/323/324/325/326/327/328/329/330/331/332/333/334/335/336/337/338/339/340/341/342/343/344/345/346/347/348/349/350/351/352/353/354/355/356/357/358/359/360/361/362/363/364/365/366/367/368/369/370/371/372/373/374/375/376/377/378/379/380/381/382/383/384/385/386/387/388/389/390/391/392/393/394/395/396/397/398/399/400/401/402/403/404/405/406/407/408/409/410/411/412/413/414/415/416/417/418/419/420/421/422/423/424/425/426/427/428/429/430/431/432/433/434/435/436/437/438/439/440/441/442/443/444/445/446/447/448/449/450/451/452/453/454/455/456/457/458/459/460/461/462/463/464/465/466/467/468/469/470/471/472/473/474/475/476/477/478/479/480/481/482/483/484/485/486/487/488/489/490/491/492/493/494/495/496/497/498/499/500/501/502/503/504/505/506/507/508/509/510/511/512/513/514/515/516/517/518/519/520/521/522/523/524/525/526/527/528/529/530/531/532/533/534/535/536/537/538/539/540/541/542/543/544/545/546/547/548/549/550/551/552/553/554/555/556/557/558/559/560/561/562/563/564/565/566/567/568/569/570/571/572/573/574/575/576/577/578/579/580/581/582/583/584/585/586/587/588/589/590/591/592/593/594/595/596/597/598/599/600/601/602/603/604/605/606/607/608/609/610/611/612/613/614/615/616/617/618/619/620/621/622/623/624/625/626/627/628/629/630/631/632/633/634/635/636/637/638/639/640/641/642/643/644/645/646/647/648/649/650/651/652/653/654/655/656/657/658/659/660/661/662/663/664/665/666/667/668/669/670/671/672/673/674/675/676/677/678/679/680/681/682/683/684/685/686/687/688/689/690/691/692/693/694/695/696/697/698/699/700/701/702/703/704/705/706/707/708/709/710/711/712/713/714/715/716/717/718/719/720/721/722/723/724/725/726/727/728/729/730/731/732/733/734/735/736/737/738/739/740/741/742/743/744/745/746/747/748/749/750/751/752/753/754/755/756/757/758/759/760/761/762/763/764/765/766/767/768/769/770/771/772/773/774/775/776/777/778/779/780/781/782/783/784/785/786/787/788/789/790/791/792/793/794/795/796/797/798/799/800/801/802/803/804/805/806/807/808/809/810/811/812/813/814/815/816/817/818/819/820/821/822/823/824/825/826/827/828/829/830/831/832/833/834/835/836/837/838/839/840/841/842/843/844/845/846/847/848/849/850/851/852/853/854/855/856/857/858/859/860/861/862/863/864/865/866/867/868/869/870/871/872/873/874/875/876/877/878/879/880/881/882/883/884/885/886/887/888/889/890/891/892/893/894/895/896/897/898/899/900/901/902/903/904/905/906/907/908/909/910/911/912/913/914/915/916/917/918/919/920/921/922/923/924/925/926/927/928/929/930/931/932/933/934/935/936/937/938/939/940/941/942/943/944/945/946/947/948/949/950/951/952/953/954/955/956/957/958/959/960/961/962/963/964/965/966/967/968/969/970/971/972/973/974/975/976/977/978/979/980/981/982/983/984/985/986/987/988/989/990/991/992/993/994/995/996/997/998/999/1000/1001/1002/1003/1004/1005/1006/1007/1008/1009/1010/1011/1012/1013/1014/1015/1016/1017/1018/1019/1020/1021/1022/1023/1024/1025/1026/1027/1028/1029/1030/1031/1032/1033/1034/1035/1036/1037/1038/1039/1040/1041/1042/1043/1044/1045/1046/1047/1048/1049/1050/1051/1052/1053/1054/1055/1056/1057/1058/1059/1060/1061/1062/1063/1064/1065/1066/1067/1068/1069/1070/1071/1072/1073/1074/1075/1076/1077/1078/1079/1080/1081/1082/1083/1084/1085/1086/1087/1088/1089/1090/1091/1092/1093/1094/1095/1096/1097/1098/1099/1100/1101/1102/1103/1104/1105/1106/1107/1108/1109/1110/1111/1112/1113/1114/1115/1116/1117/1118/1119/1120/1121/1122/1123/1124/1125/1126/1127/1128/1129/1130/1131/1132/1133/1134/1135/1136/1137/1138/1139/1140/1141/1142/1143/1144/1145/1146/1147/1148/1149/1150/1151/1152/1153/1154/1155/1156/1157/1158/1159/1160/1161/1162/1163/1164/1165/1166/1167/1168/1169/1170/1171/1172/1173/1174/1175/1176/1177/1178/1179/1180/1181/1182/1183/1184/1185/1186/1187/1188/1189/1190/1191/1192/1193/1194/1195/1196/1197/1198/1199/1200/1201/1202/1203/1204/1205/1206/1207/1208/1209/1210/1211/1212/1213/1214/1215/1216/1217/1218/1219/1220/1221/1222/1223/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