Basics of astrophysics revisited. I. Mass- luminosity relation for K, M and G class stars

Edgars Alksnis
e1alksnis@gmail.com

Small volume statistics show, that luminosity of slow rotating stars is proportional to their angular momentums of rotation. Cause should be outside of standard solar model. Slow rotating giants and dim dwarfs are not out of „main sequence” in this concept. Predictive power of stellar mass-radius-equatorial rotation speed-luminosity relation has been offered to test in numerous examples.

Keywords: mass-luminosity relation, stellar rotation, stellar mass prediction, stellar rotation prediction

> *…Such vibrations would proceed from deep inside the sun. They are a fast way of transporting large amounts of energy from the interior to the surface that is not envisioned in present theory.... They could stir up the material inside the sun, which current theory tends to see as well layered, and that could affect the fusion dynamics. If they come to be generally accepted, they will require a reworking of solar theory, and that carries in its train a reworking of stellar theory generally. These vibrations could reverberate throughout astronomy.*
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> (*Science News*, Vol. 115, April 21, 1979, p. 270).

Actual expression for stellar mass-luminosity relation (fig.1)

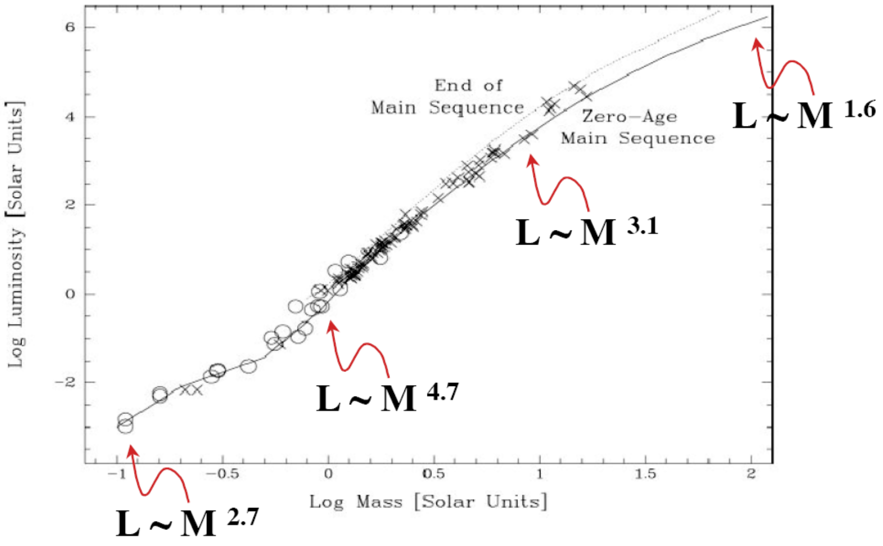

Fig.1 Stellar mass- luminosity relation. Credit: Ay20. **L-** luminosity, relative to the Sun, **M-** mass, relative to the Sun.

remain empiric and in fact contain unresolvable contradiction: stellar luminosity basically is connected with their surface area (radius squared) but mass (radius in cube) appears as a factor which generate luminosity. That purely geometric difference had pressed astrophysicists to place several classes of stars outside of „main sequence” in the frame of their strange theoretic constructions. Recent discovery that solar interior spins faster than solar surface (ESA, 2017) as well as interesting data from stellar magnetism (Georgiou, 2017) let us revisit old ideas of underestimated electro-magnetic effects in space (Bruce, 1944; Kozyrev, 2005; Juergens, 1972; Fälthammar, 2012; Lerner, 1992; Peratt, 1992; Scott, 2006; Wu et al, 2002; Clark, 2016, PSI, 2017). In such case stellar rotation should undoubtedly play a role in stellar cycle. It is generally known that heavier and hottest stars rotate faster than lighter and cooler ones, also principles of stellar gyrochronology are accepted- however stellar rotation remain marginal phenomenon in astrophysics so far.

METHOD

We have analyzed possible connection between stellar luminosity and stellar angular momentum in samples of most known K, M and G class stars (tables 1-3). Stellar equatorial rotation speed (vsin*i*) was used as main parameter of stellar rotation when possible. Several diverse data for one star were averaged. Zero stellar rotation speed was considered as an error and corresponding star has been not included in sample.

RESULTS

G class star	**Relative mass, M⊙**	**Relative radius, R⊙**	**Luminosity, L⊙**	**Relative rotation, ω_{eq}⊙**	$\frac{M*R^2*\omega_{eq}}{L}$
Mu Cassiopeiae	0.74	0.791	0.442	4.90	5.13
Sun	1	1	1	1	1
η Cas A	0.97	1.04	1.23	1.47	1.25
AK Pictoris	1.03	1.22	1.45	5.95	6.29
Lambda Serpentis	1.14	1.06	1.94	1.37	0.90
FL Lyr A	1.218	1.283	2.17	11.01	10.18
α^2 Cap A	2.05	8.38	40.4	0.16	0.56
Kappa^2 Ceti	2.46	8.23	41.7	0.06	0.23
10 Leonis Minoris	2.54	9.2	51.4	0.25	1.03
Alpha Equulei	2.3	9.2	52.5	1.05	3.90
Epsilon Ophiuchi	1.85	10.39	54	0.27	0.98
Beta Fornacis	1.53	11.02	55.8	0.10	0.32
Epsilon Andromedae	2	9.8	56	0.44	1.52
Delta Draconis	2.32	11	59	0.35	1.67
Epsilon Draconis	2.7	19	60	0.03	0.50
Eta Draconis	2.55	11	60	0.35	1.81
Chi Cassiopeiae	2.04	11	67.6	0.02	0.07
Epsilon Virginis	2.64	10.6	77	0.10	0.40
Zeta Hydrae	4.2	17.9	132	0.07	0.69
Beta Herculis A	2.9	17	151	0.06	0.32
Beta Leporis	3.5	16	171	0.33	1.74
Beta Boötis	3.4	21.5	182	0.09	0.80
ι Cnc A	3.43	21	204	3.92	29.05
24 Scorpii	2.72	21.43	204	0.12	0.73
Chi Piscium	3.17	20.65	209.2	0.23	1.51
Alpha Reticuli	3.11	12.8	240	0.22	0.46
η Peg A	3.82	18	247	0.04	0.19
Epsilon Leonis	4.01	21	288	0.19	1.15
Lambda Pegasi	1.5	28.5	390	0.14	0.42

104 Aqr A	4.23	69.5	447	0.10	4.77
Beta Draconis	6	40	1000	0.16	1.51
Kappa Trianguli Australis	7	124.6	1761	0.03	1.85
Omega Geminorum	6.3	72	1813	0.07	1.21
9 Pegasi	7.1	61	1950	0.07	0.94
δ Cep A	4.5	44.5	2000	0.10	0.44
Beta Aquarii	6.25	50	2300	0.06	0.41
Epsilon Geminorum	19.2	140	8500	0.03	1.33

Table 1. Proportional calculations for most known G- class stars.

K class star	**Relative mass, M⊙**	**Relative radius, R⊙**	**Luminosity, L⊙**	**Relative rotation, ω_{eq}⊙**	$\frac{M*R^2*\omega_{eq}}{L}$
Kepler-16A	0.69	0.6489	0.148	4.79	9.40
HD 29697	0.75	0.67	0.15	7.03	15.77
V429 Geminorum	0.63	0.71	0.17	6.84	12.77
TW Piscis Austrini	0.725	0.629	0.19	2.25	3.40
Gliese 570	0.8	0.739	0.22	0.98	1.95
83 Leonis B	0.83	0.96	0.418	0.71	1.29
Delta Eridani	1.33	2.327	3	0.21	0.50
Kepler-432 A	1.32	4.06	9.2	0.32	0.76
Eta Cephei	1.6	4.12	9.7	0.80	2.23
Praecipua	1.69	8.22	34	0.11	0.36
Lambda^2 Tucanae	1.75	8.93	37	0.17	0.64
Phi Serpentis	1.19	4.2	41.7	0.23	0.12
Delta Arietis	1.91	10.42	45	0.20	0.92
Kappa Ophiuchi	1.19	11	46	0.21	0.65
Mu Leonis	1.5	14	63	0.16	0.73
δ And A	1.3	13.6	68	0.23	0.82
63 Ceti	1.85	11.06	68.08	0.06	0.18
Chi Geminorum	1.83	14	79	0.13	0.60
Iota Hydrae	1.92	33	83	0.07	1.66
Zeta Andromedae	2.6	15.9	95.5	1.26	8.67
Iota Sculptoris	2.94	12.28	97	0.12	0.56
Chi Virginis	2.17	23	182	0.08	0.52
β Per Aa1	3.17	2.73	182	8.69	1.13
Chi Scorpii	1.09	26.76	190.9	0.14	0.59
Kappa Virginis	1.46	25.41	229	0.10	0.40
Epsilon Boötis A	4.6	33	501	0.16	1.60
Alphard	3.03	50.5	780	0.01	0.10
Omega Hydrae	4.32	48.49	944.3	0.02	0.25
Pi Herculis	3.7	72	1330	0.04	0.59
Lambda Lyrae	6.3	120	2228	0.01	0.53
Theta Herculis	4.94	89.97	2405.7	0.02	0.30
Gamma Aquilae	5.66	95	2538	0.04	0.82
Epsilon Pegasi	11.7	185	3895	0.02	2.15
Lambda Velorum	7	210	7900	0.02	0.60
Omicron^1 Canis Majoris	7.83	280	16000	0.02	0.82

Table 2. Proportional calculations for most known K- class stars.

M class star	**Relative mass, M⊙**	**Relative radius, R⊙**	**Luminosity, L⊙**	**Relative rotation, ω_{eq}⊙**	$\frac{M*R^2*\omega_{eq}}{L}$
Kapteyn's Star	0.274	0.291	0.012	15.22	29.42
Gliese 667 C	0.31	0.42	0.0137	0.23	0.93
Kepler 42	0.13	0.17	0.0024	8.25	12.92
Barnard's Star	0.144	0.196	0.0035	0.19	0.30
Kepler 138	0.57	0.54	0.06	2.45	6.78
Lacaille 8760	0.60	0.51	0.072	0.61	1.33
Alpha Gem Ca	0.60	0.619	0.0733	28.92	90.61
11 LMi A	0.964	1.003	0.755	1.36	1.75
V830 Tauri	1	2	1.2	8.93	29.77
Delta Virginis	1.4	48	468	0.06	0.42
Alpha Ceti	2.3	89	1455	0.04	0.47
Beta Pegasi	2.1	5	1500	0.94	0.03
Beta Andromedae	3.5	100	1995	0.03	0.61
Rho Persei	5	150	2290	0.04	1.78
Antares A	12.4	883	57500	0.01	1.84
Betelgeuse	11.6	887	120000	0.003	0.21
RW Cygni	20	680	145000	0.04	2.69

Table 3. Proportional calculations for most known M- class stars.

DISCUSSION

M, K and G class stars together represent more than 96% of stellar population. Given that stellar masses are determined indirect, accurate stellar equatorial rotation speeds are hard to obtain and there are sometimes methodic problems with estimation of hyper spectral luminosity of stars, first results of connection stellar luminosity- stellar angular momentum look promising. Method represents first independent path to check reliability of astrophysical estimations. From data is clear, that giants and dwarfs of classes G, K and M stars are not out of „main sequence".

From other side, we see for example undoubtedly errors in stellar rotation speed data of AK Pictoris, FL Lyr A (table 1), Kapteyn's Star, Alpha Gem Ca and V830 Tauri (Table 3).

PREDICTIONS

Stellar angular momentum-stellar luminosity relation can be used for:
1. determination of stellar mass from known radius, equatorial rotation speed and luminosity,
2. estimation of stellar equatorial rotation speed from known radius, mass and luminosity,
3. determination of stellar luminosity from known radius, mass and equatorial rotation speed.

In tables 4,5 we are giving certain predictions for unknown parameters of some K, M and G class stars.

Star	**Radius**	**Luminosity**	**Rotational velocity, km/s**	**Prediction of mass (M⊙)**
Mu Persei	53	2020	12	4.6
HD 180262 A	50	323	1.4	6.5
Eta Persei	44	5135	5.8	29

Table 4. Prediction of stellar mass from known radius, equatorial rotation speed and luminosity.

Star	**Mass**	**Radius**	**Luminosity**	**Prediction of relative stellar angular rotation speed**
Delta Leporis	0.94	10	45.7	0.34
RY Andromedae	1.34	308	5623	0.031
VY Canis Majoris	17	1 420	270000	0.0055
V382 Carinae	20	700	316000	0.022

Table 5. Estimation of stellar equatorial rotation speed from known radius, mass and luminosity.

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