A SPECTROSCOPIC ANALYSIS OF PECULIAR STARS IV. THE STRONTIUM GROUP

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About 1500 lines of the Ap strontium star HR 710 were identified on a Coudé plate having a dispersion of 4,5 A/mm. The behavior of the different elements is analysed, specially of those at the iron peak. It is concluded that this star is very similar to the Am stars.

The paper in full will be published elsewhere.

OBSERVATIONS OF LUNAR OCCULTATIONS OF THE GALACTIC CENTER REGION IN THE OH AND HYDROGEN LINES

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A series of lunar occultations of the galactic center region is being observed with the 140 foot telescope at Green Bank, West Virginia. In line observations, the main interest lies in the fine structure of the absorbing clouds of OH or HI in front of the continuum sources near the center.

The +40 km/sec component of the OH absorption spectrum is found to originate in a cloud of dimensions 3' x 5', which appears to rotate as a uniform body. Internal structure has been detected in the -130 km/sec component of the order of 30". The results for the 1665 and 1667 MHz lines are significantly different.

This paper has now been published in Astrophysical Letters, 2, 195 - 200 (1968).

UNSTABLE [illegible] OF GALAXIES(+)

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Abstract: The observed relationship between mass-luminosity ratios for groups and clusters of galaxies and their population is inter-

preted on basis of a model developed by the author (1968) in which unstable groups of galaxies are thought to be the result of the fragmentation of a parent galaxy.

1- In a former paper (Sérsic, 1968=paper I, henceforth) we have developed a model for galaxy formation through fragmentation of giant ellipticals. We shall give here a restricted formulation of the model which seems to fit the observed properties of groups and clusters of galaxies.

Let us recall the relationship of paper I,

$$T_o = \Sigma T_i + T_1 + \mu c^2 - (d^2J/dt^2)$$

where T_o, T_1 and the T_i's are respectively the kinetic energies of the parent galaxy prior to the explosive event, the fragments after the explosive event, and the system of fragments. μc^2 is the energy radiated when the nucleus of the parent galaxy collapses and J the moment of inertia of the system of fragments. We shall assume that the system of fragments is unstable, so that (see the Appendix) $d^2J/dt^2 = c^2 \mu$.

With the above hypothesis we readily have for the specific energies,

$$T_o/M_o = T/M + T_1/M_o$$

after introducing the average values of the T_i's and M_i's through $nT = \Sigma T_i$ and $nM = \Sigma M_i$, n being the number of fragments.

For T_1 we have the relationship

$$T_1/M_o = 1/2(\mu /M_o)c^2 - 1/2(W_1/M_o)$$

where W_1 is the potential energy of the system of fragments. The assumed relation $J'' = \mu c^2$ implies the expansion of the system of fragments. After a time considerably longer than the dynamical time-scale of the parent system, $-W_1$ will become much smaller than μc^2 and $T_1 = 1/2 \mu c^2$ will be a good approximation.

Eq. (4) of paper I is written now

$$1 - s^2 = 1/nr + h^2r^2$$

where $s^2 = 1/2 \mu c^2 R_o/M_o$, and $1/m = n = M_o/M$ is the number of fragments resulting from the violent event. s means the expansion rate

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of the unstable group of fragments long time after the explosion, given in units of the velocity dispersion $\sigma^2 = M_o/R_o$ of the parent galaxy. Expression (1) relates s to the group population n and to the average effective radius r of their galaxies. If we assume a maximum possible rate of expansion, so that $ds^2/dt = 0$, we find

$$s_M^2 = 1 - 3(h/2n)^{2/3}$$

because the effective radius at the maximum is related to the group population through $r_M^3 = 1/2h^2n$. We see now that in this model the expansion rate only depends on n.

It is customary to estimate the masses of groups of galaxies through the virial theorem, assuming their steady state. The masses calculated in that way are exaggerated, and it is a matter of discussion whether this is so because extra matter is not considered or because the assumption for a steady state fails.

Let us write M° for the total mass of a group of galaxies computed through the virial theorem and R_1 be the radius of the system, A a numerical factor and G the gravitational constant. We then have

$$M^{\circ} = (A/G)\ \sigma_1^2 R_1 = (A/G)\ \sigma_1^3\ t$$

where σ_1 is the velocity dispersion of the group of galaxies and t the time elapsed since the explosive event. Now, as in paper I, $\sigma_1 = s\ \sigma_o$ and taking k = 1/2 for the sake of clarity, we get

$$M^{\circ} = (A\sigma_o^3/G)\ (1 - 3/4\ n^{-2/3})^{3/2} .t$$

the biased mass derived from the virial theorem.

Let $f = M_o/L$ be now the true average mass-luminosity ratio of the group, and f° the same ratio, but derived with the biased mass M°. We have then

$$f^{\circ} = f.(\sigma_o/R_o)(1 - 3/4\ n^{-2/3})^{3/2} .t$$

recalling that $M_o = (A/G)\ \sigma_o^2\ R_o$ is the mass of the parent galaxy. Introducing now the dynamical time-scale $\tau = R_o/\sigma_o$ of the parent galaxy, finally results

$$f^{\circ} = f(1 - 3/4\ n^{-2/3})^{3/2} .(t/\tau)$$

an expression that evidences the dependence of f° on the population n and the age t of the group of fragments.

Figure 1 has been borrowed from a paper of I.D. Karachtensev (1966) where the mass-luminosity ratios for several groups and clusters are discussed. We have adapted to the figure a pair of curves computed with the above relationship which gives a reasonable good fit of the points in the diagram. If we assume an age of 10^{10} years for the Metagalaxy, we find that small groups with 3-30 members should be only $2,5 \times 10^9$ years old. A similar diagram due to T.L. Page (1965) is given in figure 2.

The discussion of equation (1) in paper I showed galaxies with small r should be ellipticals because the angular momentum per unit of mass hr^2 is a fortiori very small. This conclusion allow us to arrive at another, regarding the dominant type of galaxy in a group or cluster. In fact, the larger n is, the smaller will be $r_M = 1/2\ h^2 n$ in case of efficient expansion, and the average galaxy must be of early type. So we would expect large clusters to be populated mainly by E-SO galaxies and be of a regular spherical structure because the high value of s ($\simeq 1$) would not allow for large statistical fluctuations in the velocity dispersion. A less efficient expansion will probably broaden the spectrum of galaxian types, but then s will be smaller, statistical fluctuations will become important and the cluster will loose its regular structure. We think this is the case for large clusters and clouds containing many spirals and irregular galaxies.

To end, we may include in this picture the field galaxies, also discussed in paper I. If we assume again that fragmentation proceeds with maximum efficiency and recall that $s^2 = 0.75$ (q_c in paper I) for field galaxies, we get

$$\bar{n} = 21\ h = 5 \text{ to } 10$$

for the average number of galaxies per fragmentation event. Here we took k = 1/4 or 1/2. This estimate of $\bar{n}$ agrees well with the average population of these loose groups of galaxies which are believed to constitute the 'field' (de Vaucouleurs, 1968).

REFERENCES

1- Karachtensev; 1966, Astrofizika.

2- Page T.L., 1965, Smithsonian Special Report N° 95.

3- Sérsic J.L., 1968, BAC, 19, N°3, p.105.

4- de Vaucouleurs G., 1968, Stars and Stellar Systems, IX, ch.17, Chicago, Univ. Press.

Appendix:

Assume a mechanical system in steady state, so that the kinetic (T) and potential (W) energies are linked by

$$2T + W = 0$$
$$T + W = -E^B \qquad (1)$$

where $E^B > 0$ is the binding energy. Let us imagine now that the equilibrium mass distribution has a dense core which collapses in a short scale of time radiating an energy pulse $1/2\ \mu c^2$. The potential energy W will be, before the event,

$$W = W_o\ (1 + \frac{\mu}{AM}) - 1/2\ \mu\ c^2$$

where W_o is the potential of the mass distribution without the core, $\frac{\mu W_o}{AM}$ the interaction energy between the core and the rest of the system and $-1/2\ \mu c^2$ the potential energy of the core itself.

After the collapse of the core, the new configuration is controlled by the relations

$$2T + W_o = 1/2\ \mu c^2 - \frac{\mu}{AM} W_o$$
$$T + W_o = 1/2\ \mu c^2 - \frac{\mu}{AM} W_o - E^B \qquad (2)$$

In case of unstability we have

$$1/2\ J'' = 2T + W_o = 1/2\ \mu c^2 - \frac{\mu}{AM} W_o > E^B = T$$

the last relation coming from (1). If we introduce the velocity dispersion σ associated with $T = 1/2\ M\sigma^2$ (M is the total mass of the system) we easily get

$$(\frac{\mu}{M}) > \frac{\sigma^2}{c^2+\sigma^2} \qquad (3a)$$

for the unstable condition. On the other hand, if

$$(\frac{\mu}{M}) < \frac{\sigma^2}{c^2+\sigma^2} \qquad (3b)$$

the system is stable and

$$1/2\ J'' = 1/2\ \mu c^2 - \frac{\mu}{AM} W_o < E^B = T$$

which means that stable vibrational modes are excited. The condition (3a) with $\sigma << c$ is assumed in the text.

Introducing now the absolute value Φ of the average potential corresponding to W, the first equation of (1) gives $\sigma^2 = \Phi$ and (3) may be written

$$\Phi \lessgtr c^2(\mu/M)/(1-\mu/M)$$

for respectively unstable and stable configurations after the collapsing of the core.

A.G. Wilson(1) has discussed the observational evidence for the existence of a potential bound $\Phi \leq 10^{-4.3}c^2$ for astronomical systems (galaxies, groups and clusters of galaxies): later on, D. Edelen and A.G. Wilson (2) accept the upper bound for Φ as "an observed fact whose significance is uncertain". The foregoing results suggests a simple interpretation. In fact, if cosmic systems are the result of a hierarch of fragmentation processes through succesive explosions and the resulting systems of fragments are unstable, an upper bound for Φ is found, namely

$$\Phi \leq c^2(\mu/M)(1 - \mu/M)$$

which together with the figure given by Wilson, requires that a given fraction of the mass of the parent system must be radiated away in order to fly it to pieces. Such a result is not surprising when we think that all parent systems (cD galaxies for example) follow the same structural pattern. This means approximate homologous conditions in the growth and developement of the core, and the existence of a critical fractional mass $(\mu/M)_c$ for unstability. From Wilson's figures $\mu/M = 5.10^{-5}$ which gives a mass of the order of 10^8 suns for a giant D galaxy with $M = 2.10^{12}$ suns. These figures together with the foregoing interpretation of the upper bound for Φ, mean that the system of fragments is always unstable (See paper I).

(Ver figuras en páginas 111 y 112)

REFERENCES

(1)- A.G. Wilson; A.J. 71, 402, 1966.
(2)- D. Edelen and A.G. Wilson Ap.J., 151, 1171, 1968.

SOLUCION NUMERICA DEL PROBLEMA DE KEPLER EN VARIABLES UNIVERSALES

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Cuando se trata de resolver en la forma clásica el problema de encontrar la posición sobre una órbita, correspondiente a un sistema dado, se hace necesario resolver una de las tres ecuaciones de Kepler. Aquí reducimos esas ecuaciones a una forma standard expresada mediante las variables y funciones universales introducidas por Herrick, Stumpf y otros. La solución se obtiene resolviendo primero una ecuación cúbica que representa aproximadamente la forma standard mencionada. Esta primera aproximación, que constituye una modificación de la ecuación de Kepler para el caso parabólico, es bastante buena para todas las excentricidades comprendidas en el intervalo (0,1.5); los casos más favorables se presentan cuando las posiciones son cercanas al pericentro. Luego se calculan sucesivas correcciones de la primera aproximación para lo cual se debe resolver en forma reiterada una ecuación cuadrática o bien cúbica. En el primer caso, que es equivalente a una corrección del tipo Newton-Raphson cuadrática, se da un criterio para elegir la raiz que corresponde al problema y se encuentra que dos correcciones sucesivas dan en todos los casos por lo menos 8 cifras significativas correctas. En el caso de la corrección cúbica se da un esquema sencillo para el cálculo numérico.

En varios gráficos se hace una descripción detallada del grado de precisión obtenido en todos los casos y con diversas aproximaciones.

Se estudian algunas propiedades analíticas de las variables y funciones universales introducidas en el problema.

LA ABSORCION EN EL ESPECTRO CONTINUO DE LA RADIOFUENTE 18SIA ASOCIADA A LA NEBULOSA GASEOSA N.G.C. 6618

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Con el radiotelescopio de Pereyra de 0°.46 HPW de antena en