



VESOLJE-SI

CENTER ODLIČNOSTI VESOLJE, ZNANOST IN TEHNOLOGIJE

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Naložba v vašo prihodnost

OPERACIJO DELNO FINANCIRA EVROPSKA UNIJA
Evropski sklad za regionalni razvoj
Konezijska akcija
Prepisi socialni sklad

Jate galaksij velikani vesolja



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Center Odličnosti Vesolje-SI
in Univerza v Ljubljani

Ljubljana, 3. maj 2012

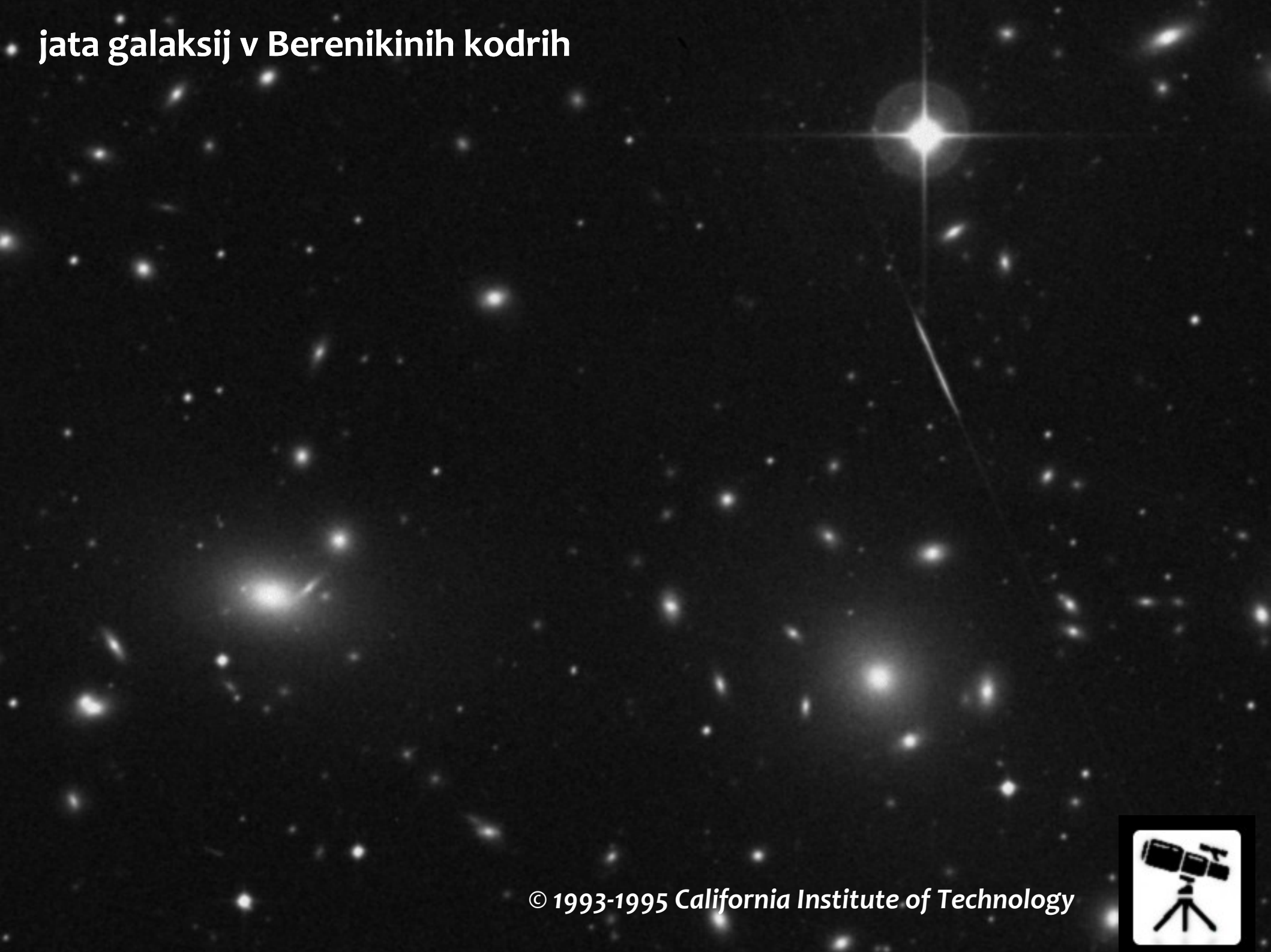
jata galaksij v Berenikinih kodrih

“that remarkable collection of many hundreds of nebulae which are to be seen in what I have called the nebulous stratum of Coma Berenices”

F.W.Herschel, *On the construction of the Heavens*, 1785



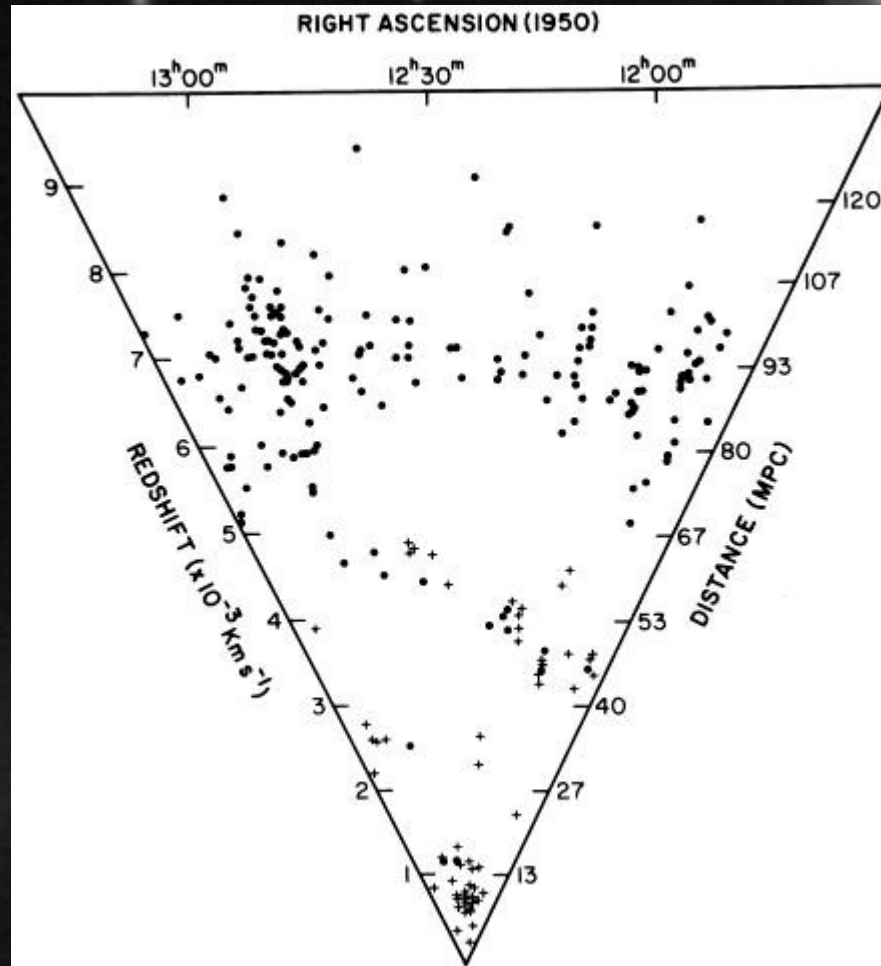
jata galaksij v Berenikinih kodrih



© 1993-1995 California Institute of Technology



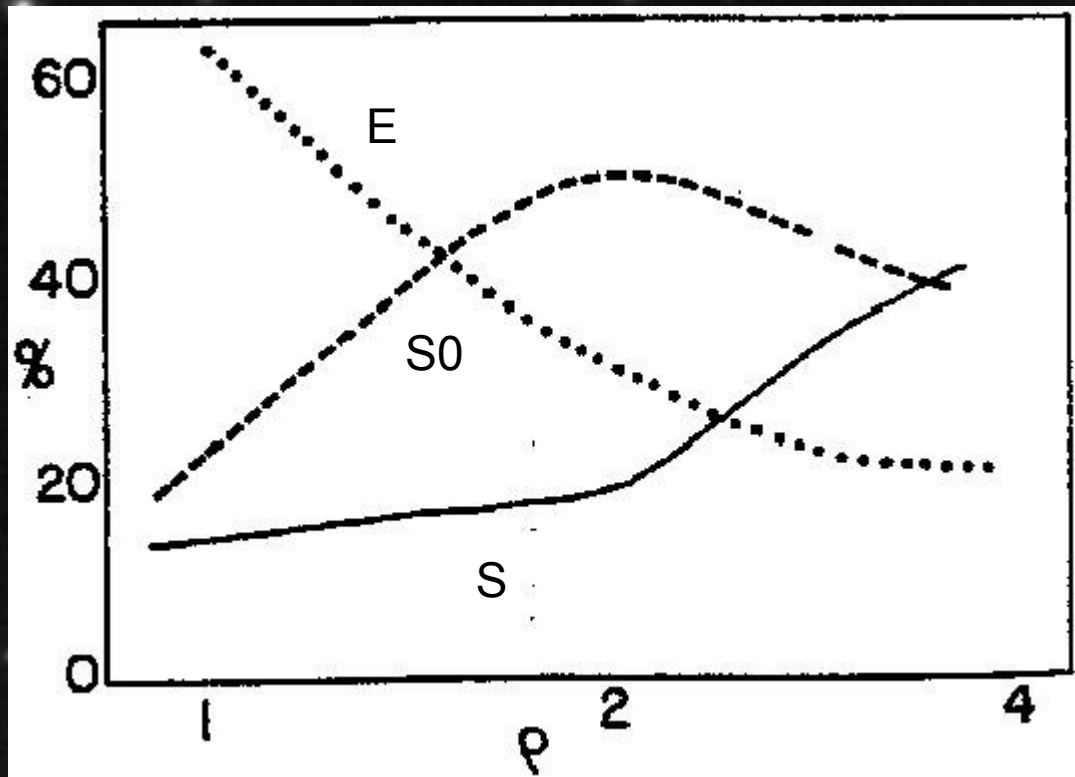
jata galaksij v Berenikinih kodrih



Gregory & Thompson 1978



Galaksije v jatah galaksij



Oemler 1977



Fritz Zwicky in manjkajoča masa

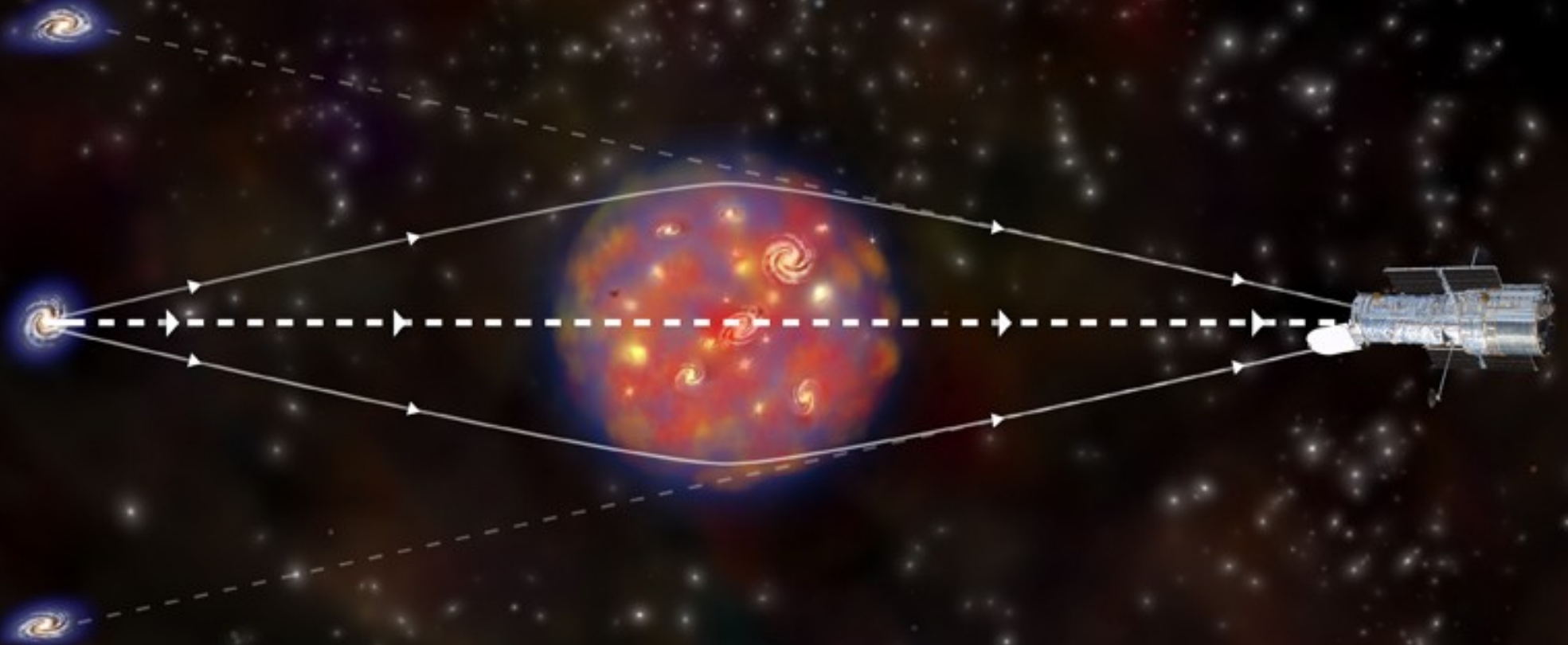


$$\frac{M}{L} = \frac{68 \times M_{sun}}{L_{sun}}$$

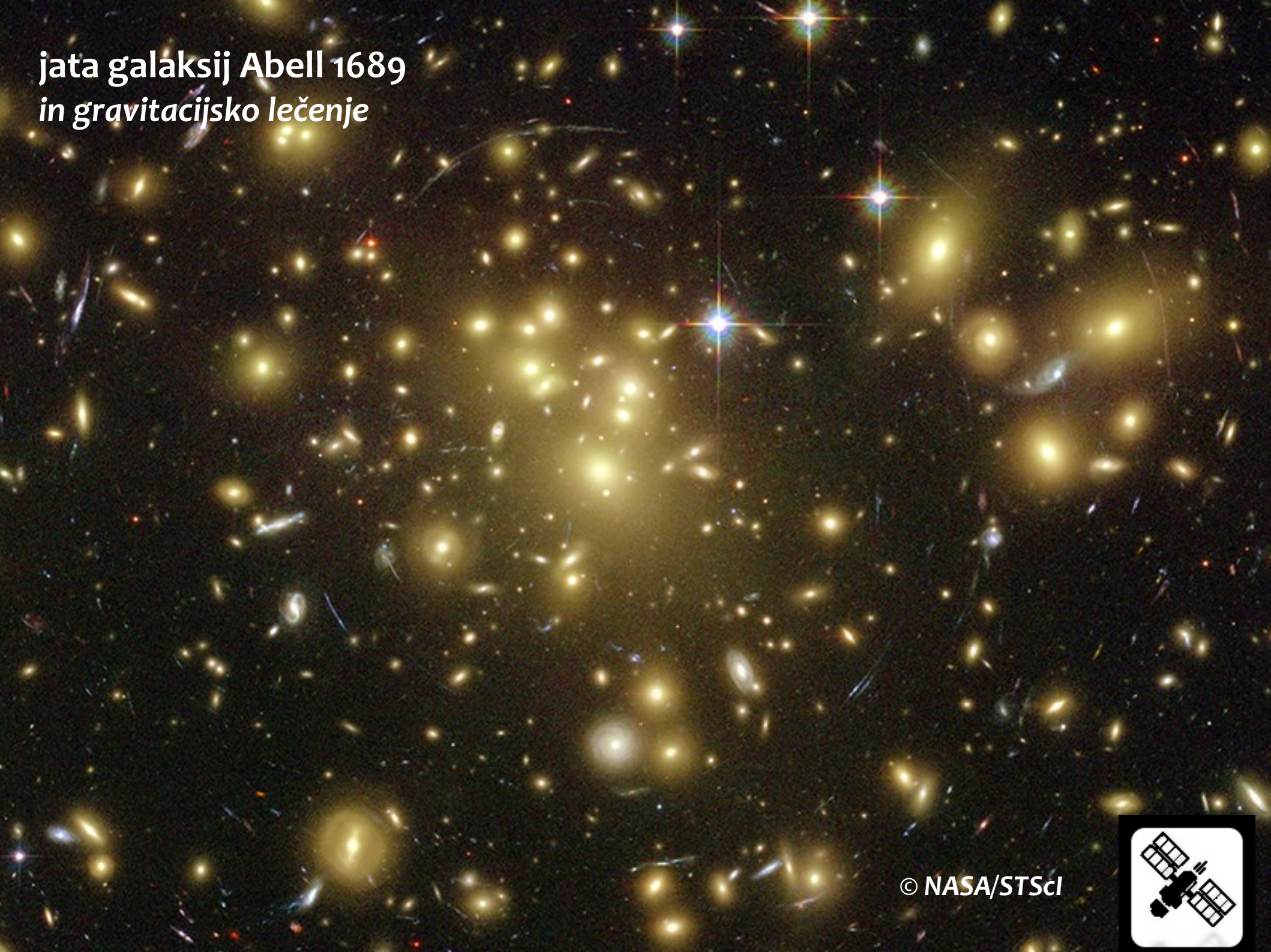
On the Masses of Nebulae and of Clusters of Nebulae, 1937



Gravitacijsko lečenje

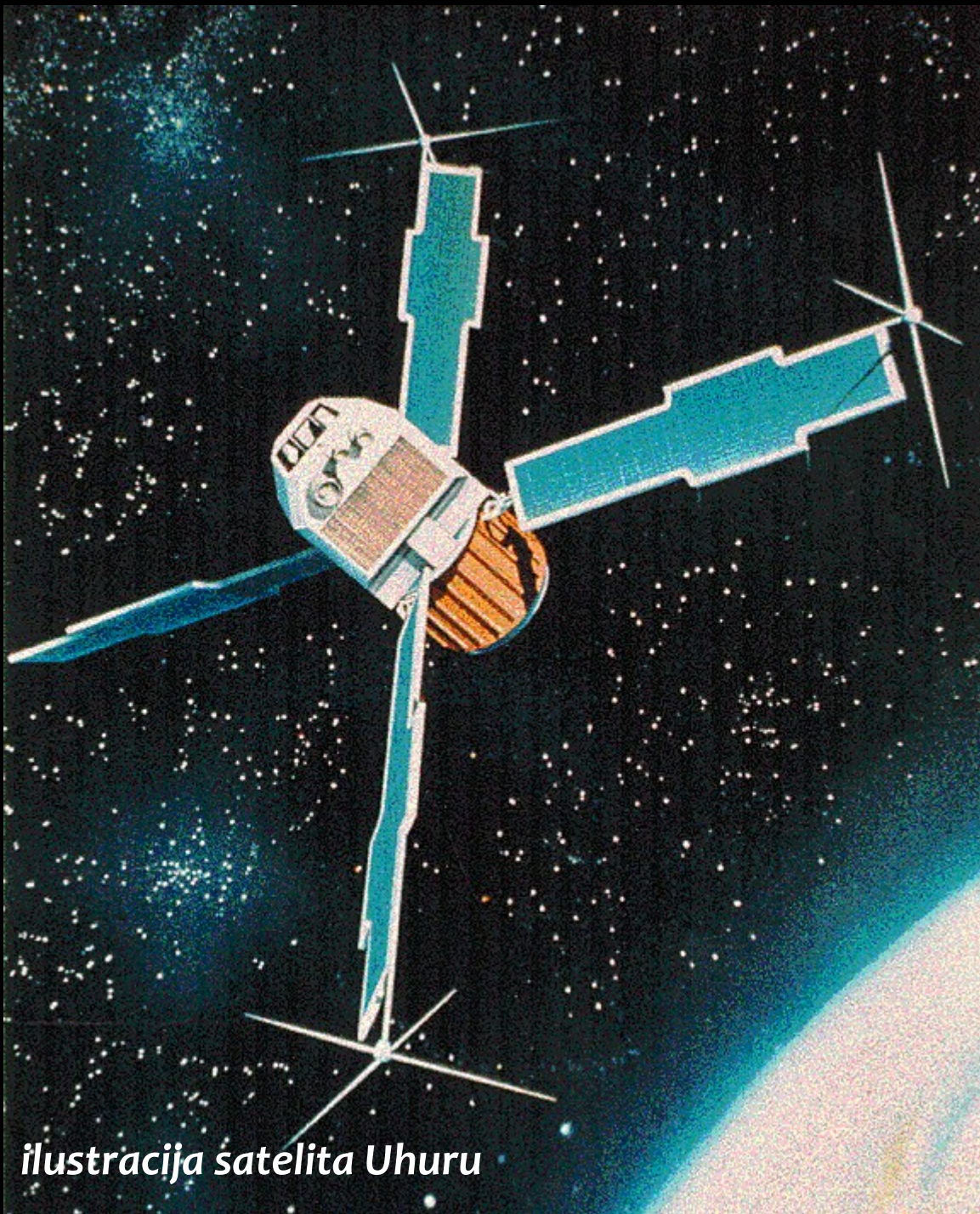


jata galaksij Abell 1689
in gravitacijsko lečenje



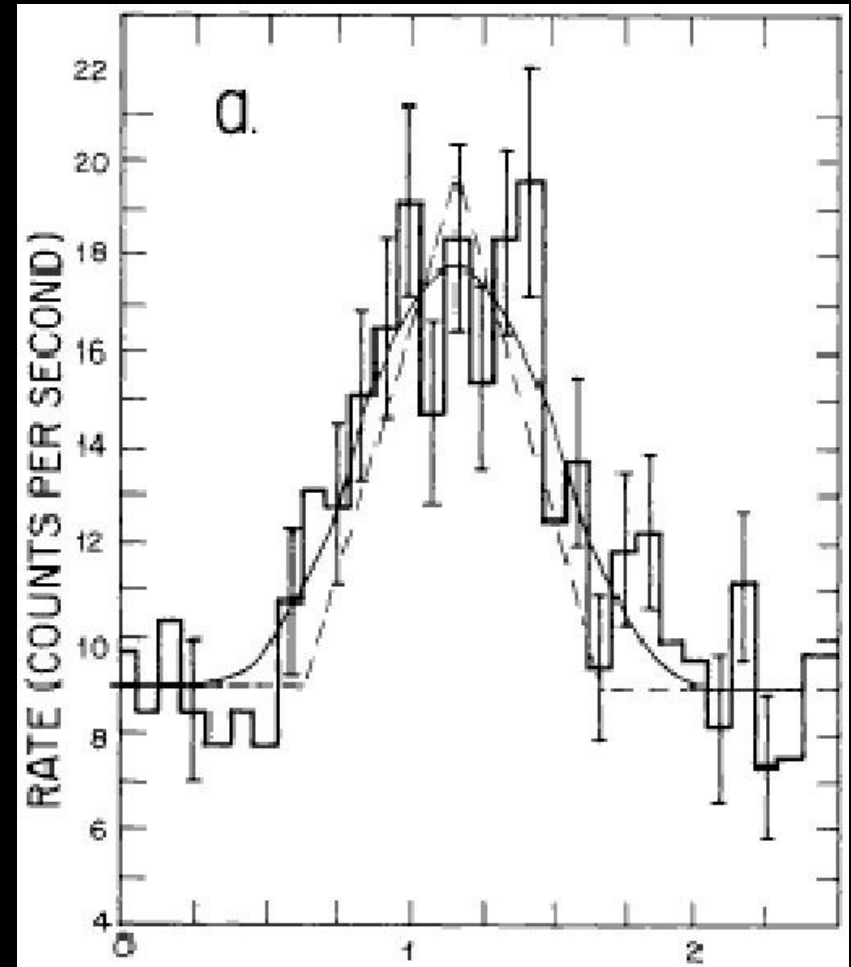
© NASA/STScI





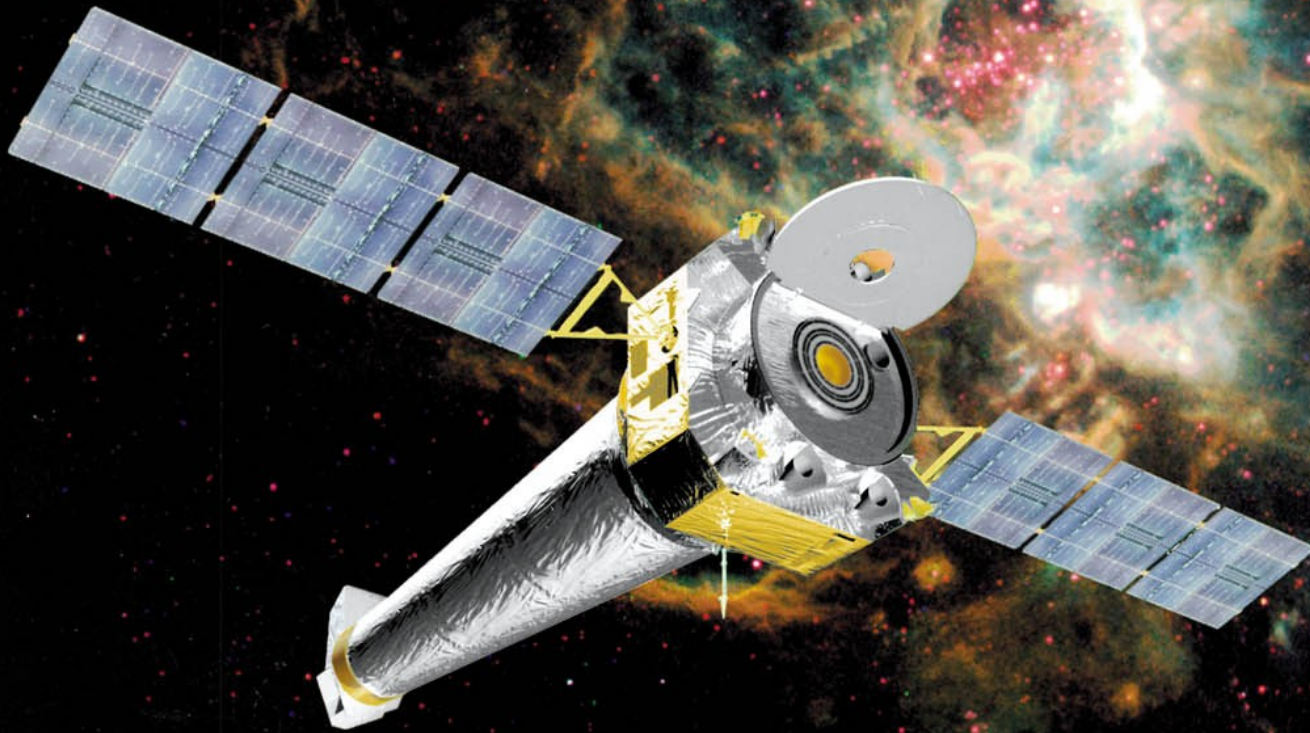
ilustracija satelita Uhuru

prva opazovanja
rentgenskega sevanja v jatah



Gursky 1971

rentgenski teleskop Chandra



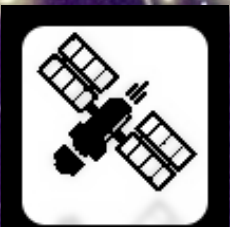
© NASA (umetniška ponazoritev teleskopa in meglica v ozadju)

rentgenski fotoni iz jate galaksij Abell 1689
kažejo porazdelitev ioniziranega plina

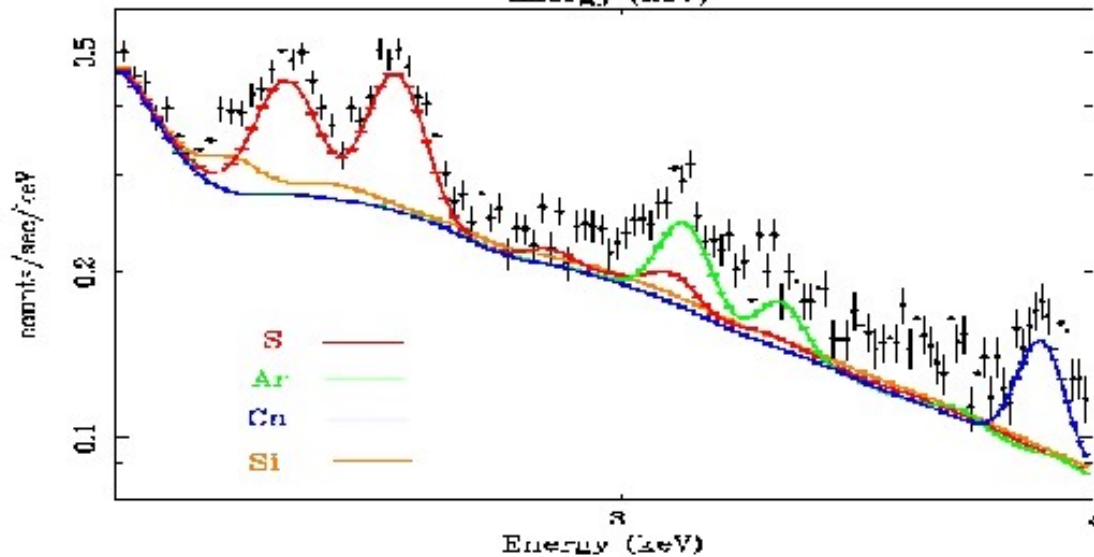
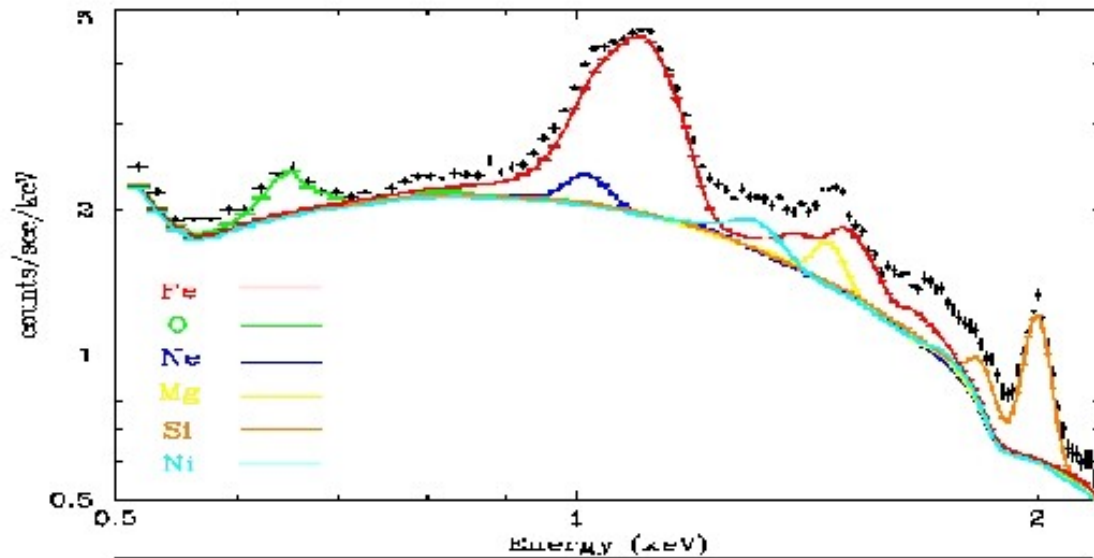
© NASA/CXC/MIT/E.-H Peng et al.



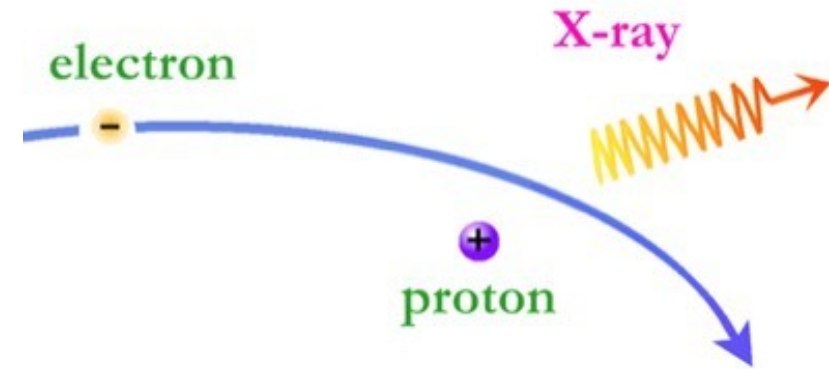
sestavljene pogled na jato Abell 1689



Zakaj so rentgenska opazovanja pomembna?



M87/Virgo (cluster core)

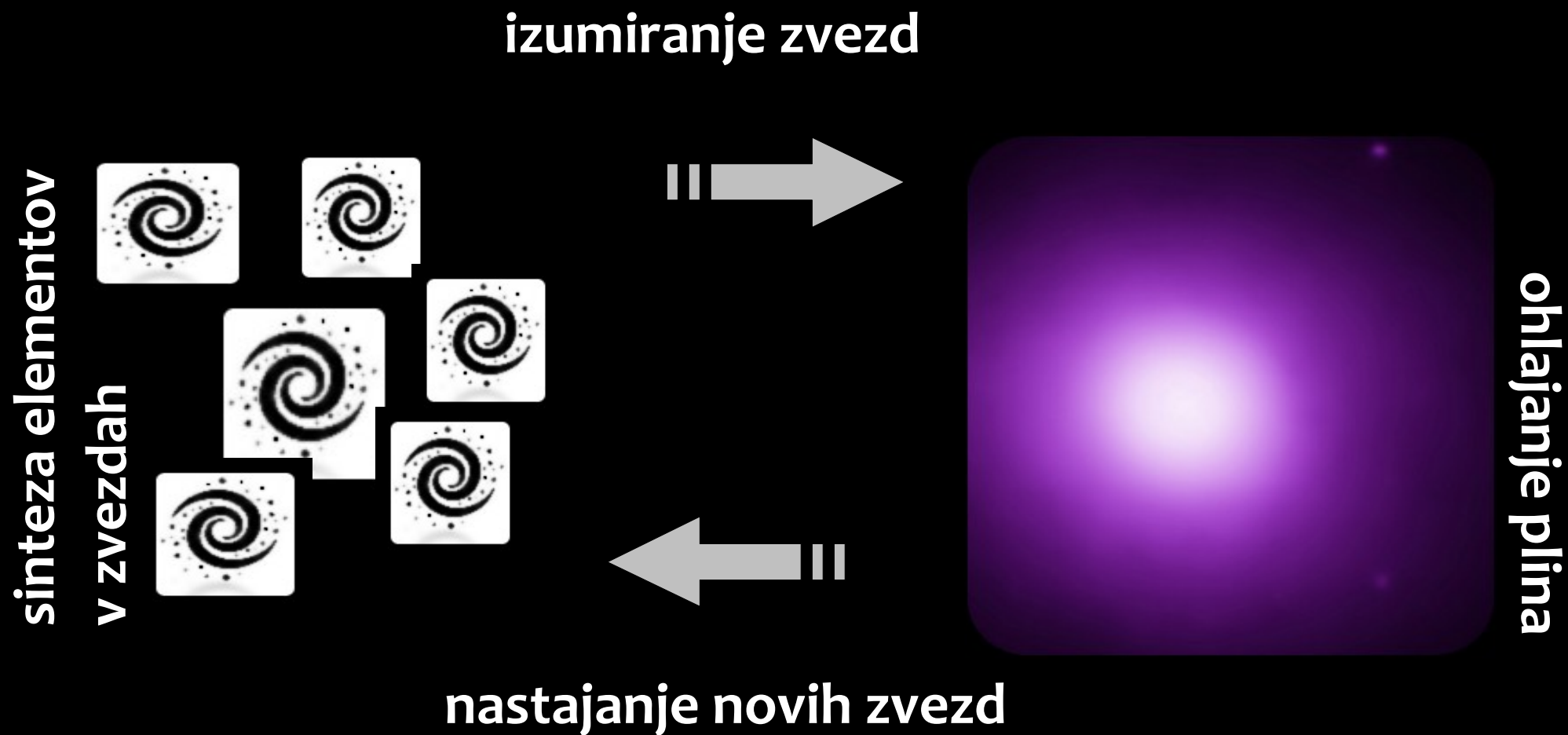


continuum: zavorno sevanje

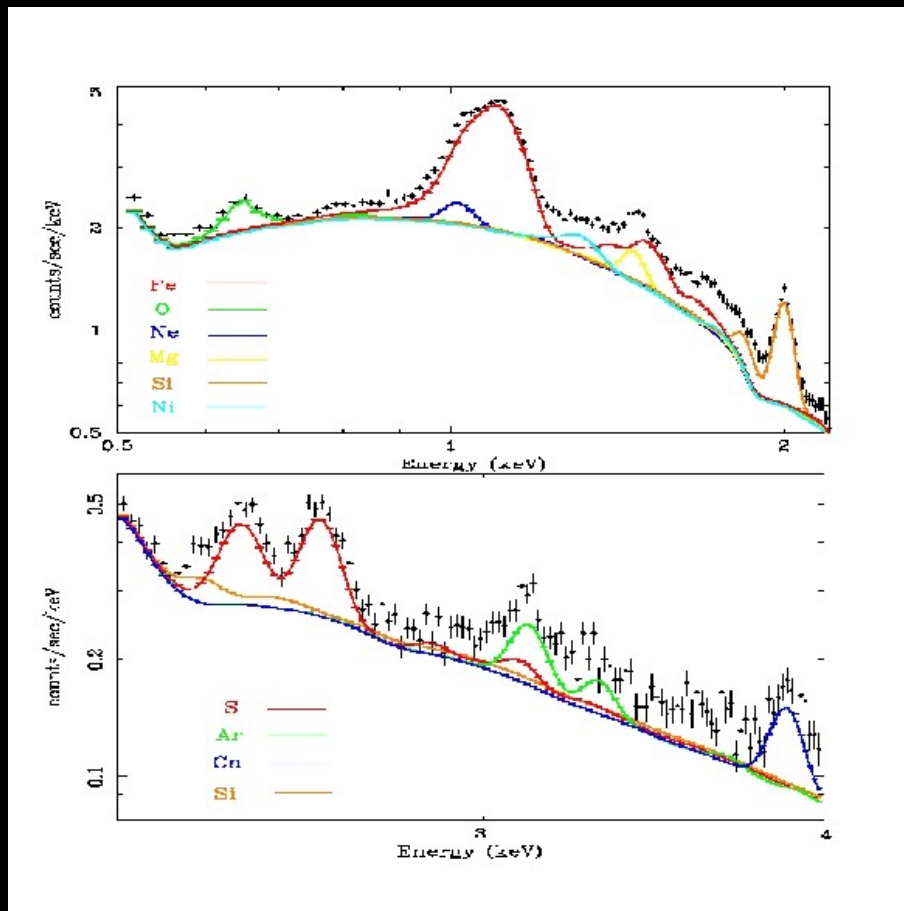
$$\frac{dL}{dV} = 1.4 \times 10^{-27} T^{1/2} n_e^2 Z^2 \text{ erg s}^{-1} \text{ cm}^{-3}$$

emisijske črte: ionizirani elementi

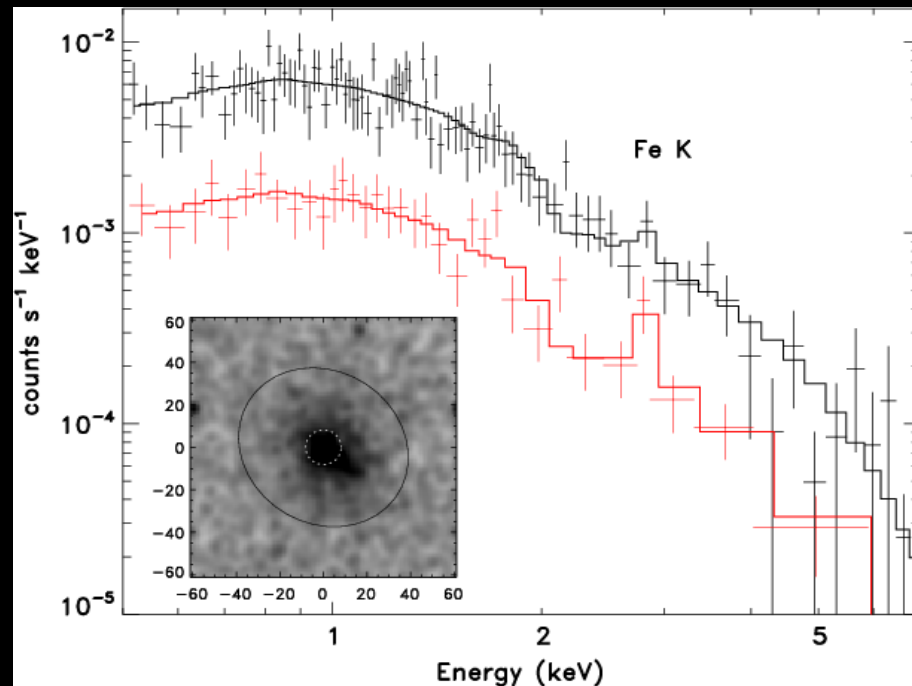
Obogatitev plina s kemičnimi elementi



Zakaj so rentgenska opazovanja pomembna?



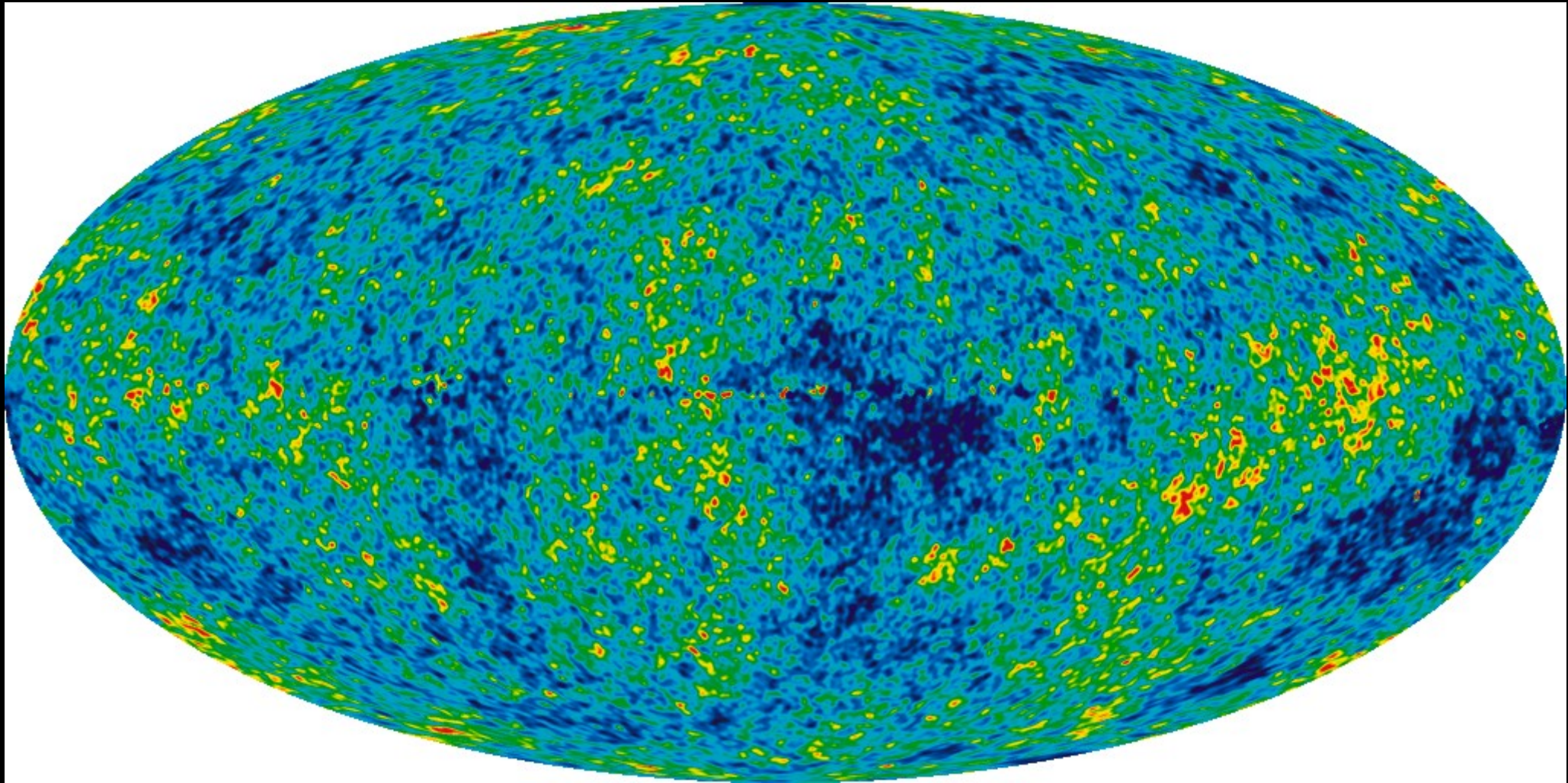
Gastaldello & Molendi 2002



Rosati et al. 2009

- kemična sestava plina
- temperatura plina
- oddaljenost jate

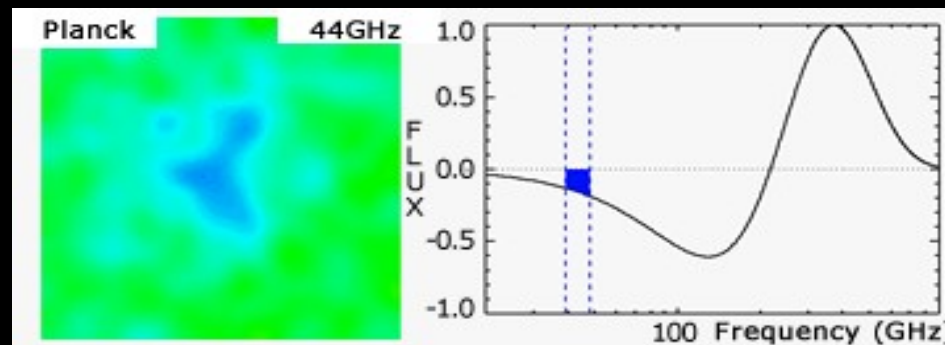
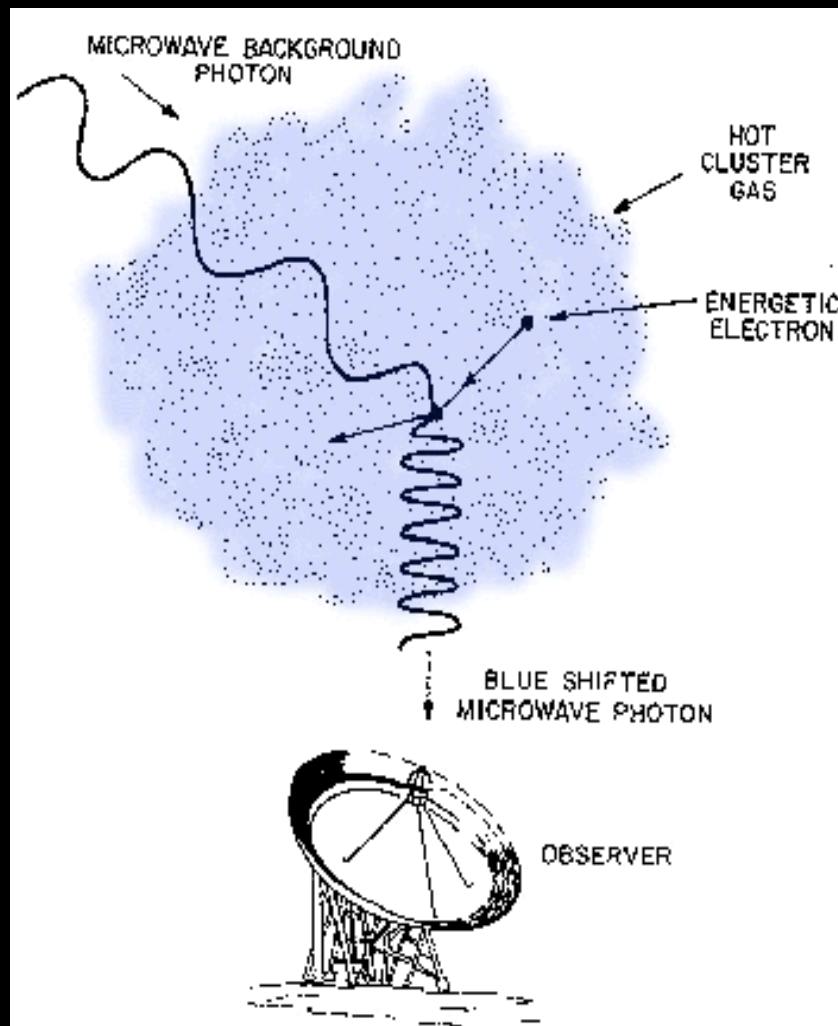
Jate in prasevanje



WMAP

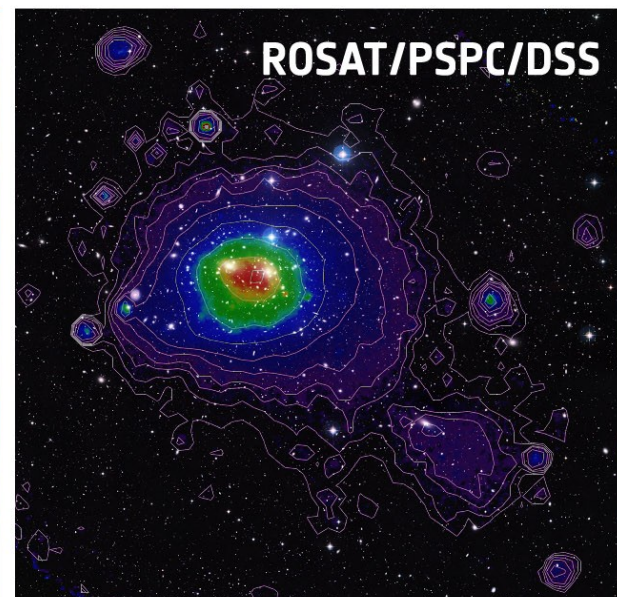
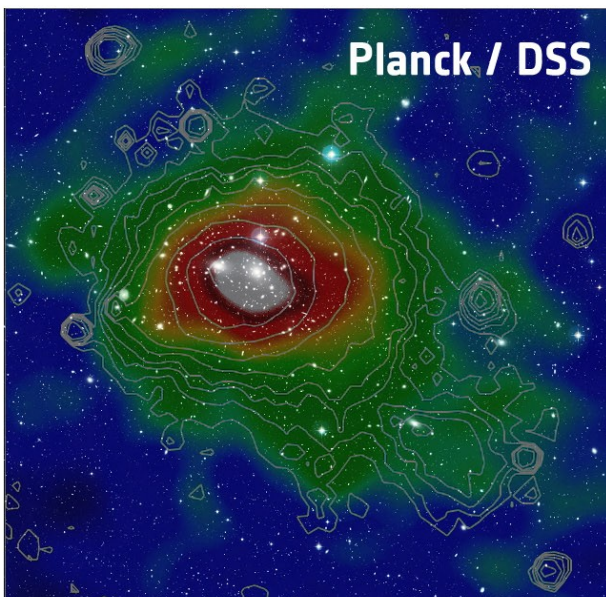
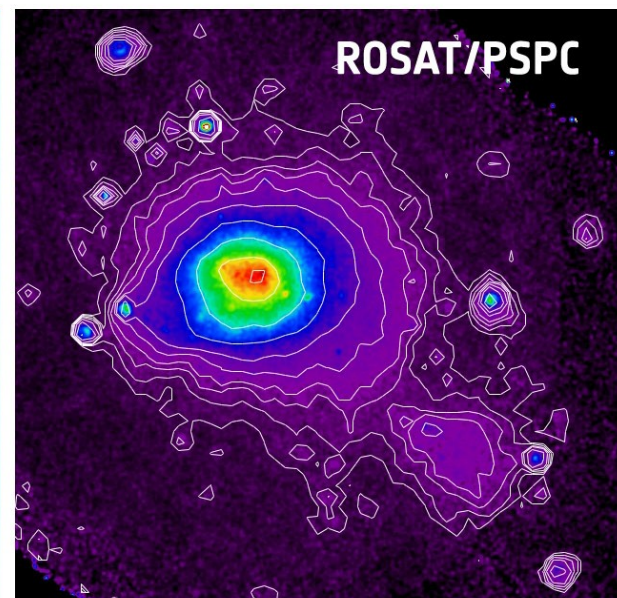
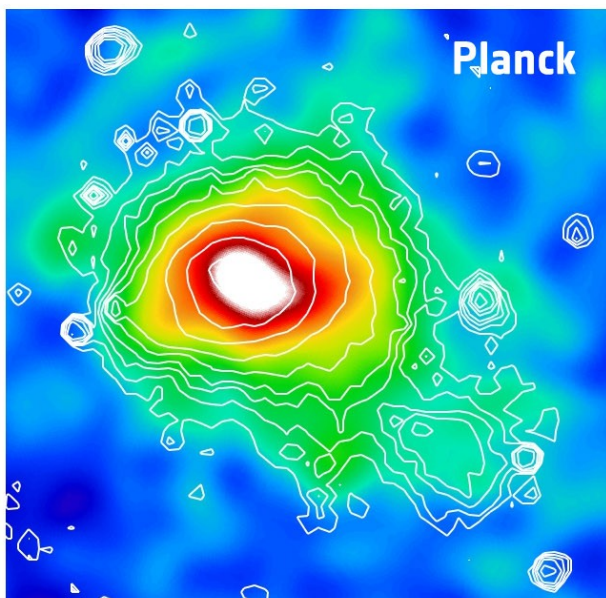


Jate in prasevanje

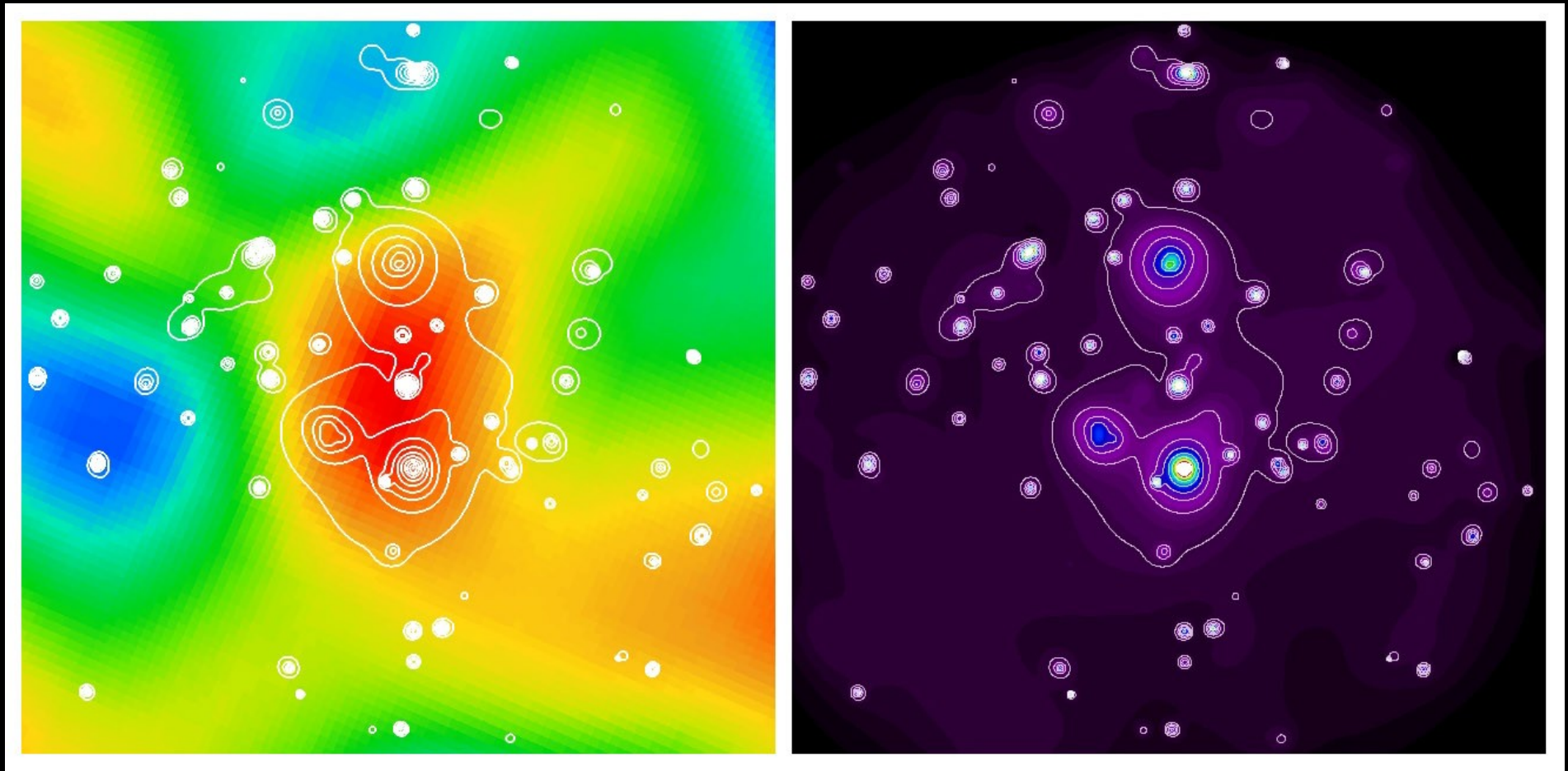


efekt Sunyaev-Zeldovič

Pogled na jato v Berenikinih kodrih



Pogled na oddaljeno nadjato (PLCK 226.6-27.3)



ESA / HFI & LFI Consortia (Planck), ESA (XMM)

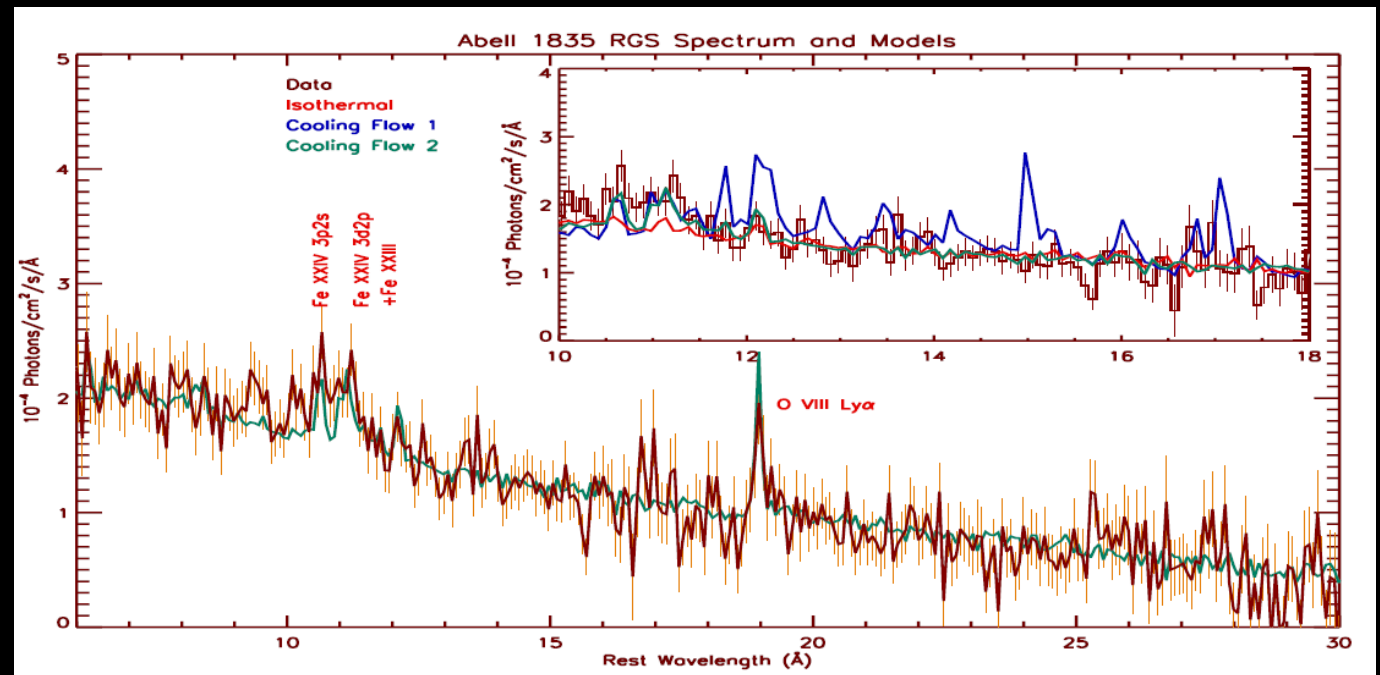


Jate in problem hladilnih tokov

Izsev jate
s hladilnimi tokovi

$$L_{cool} = \frac{5}{2} \frac{\dot{M}}{\mu m} kT$$

$$\dot{M} \sim 100 M_{sun} / yr$$



Peterson et al. (2001)

Opazovanja (XMM Newton):

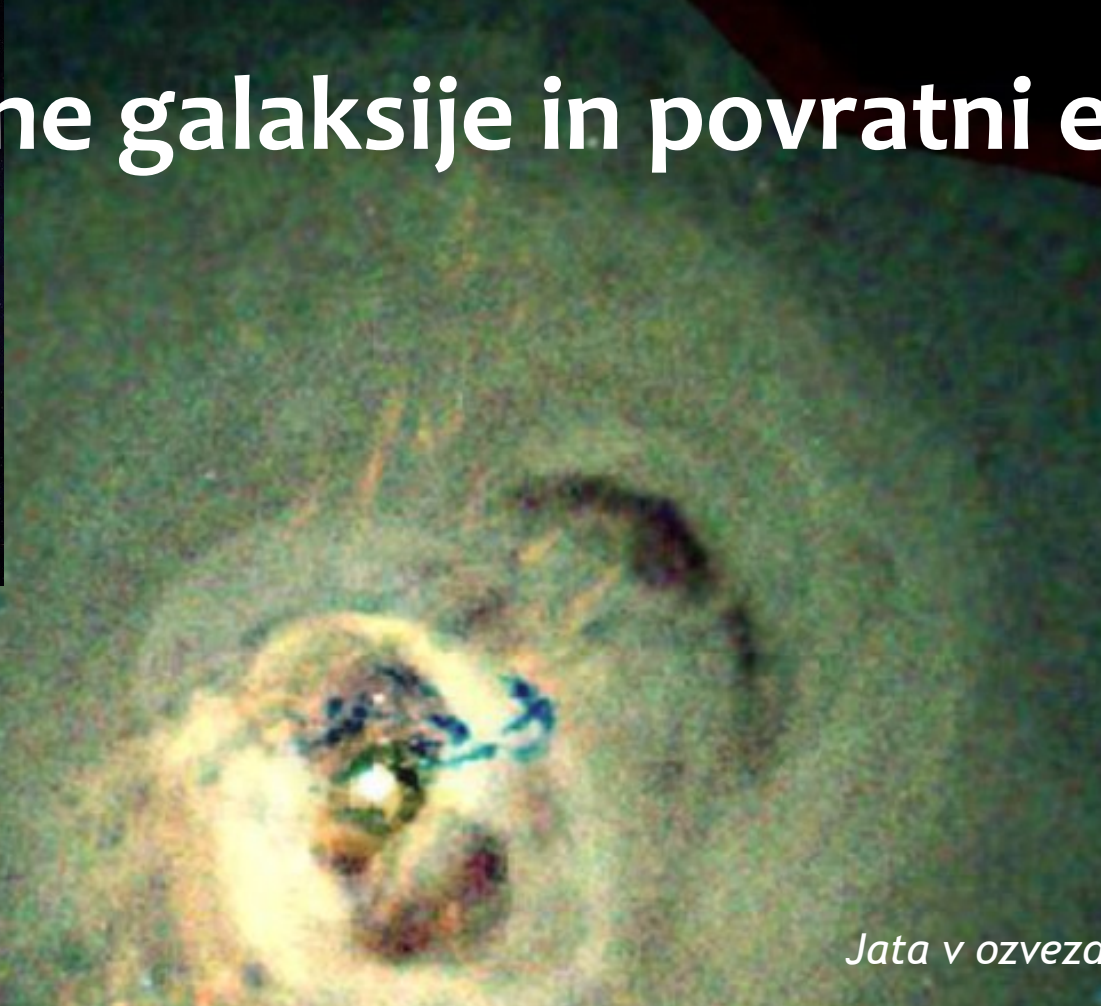
$$\dot{M} \sim 10 M_{sun} / yr$$

ni plina z nizkimi temperaturami

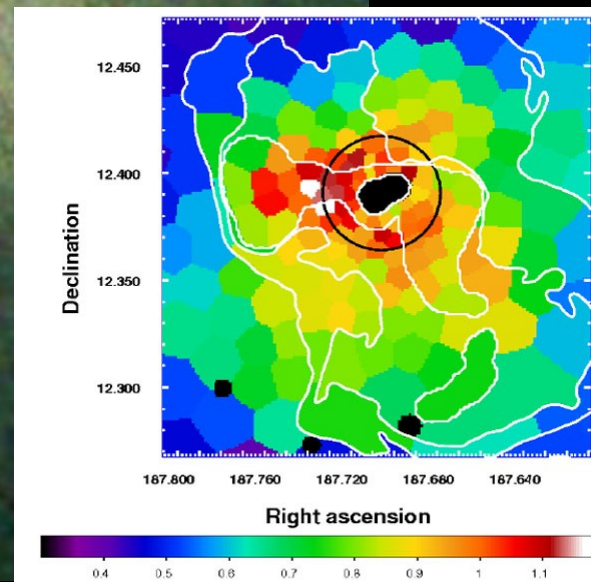
Aktivne galaksije in povratni efekt



Jata v Perzeju



Jata v ozvezdju Device

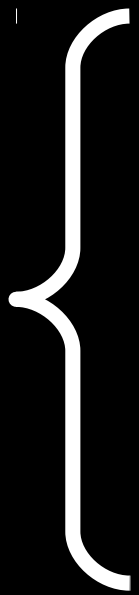


*Fabian et al. 2005,
Simionescu et al. 2009*



Znana snov 10%

Temna snov 90%



1000x



15%



85%



jata Metek

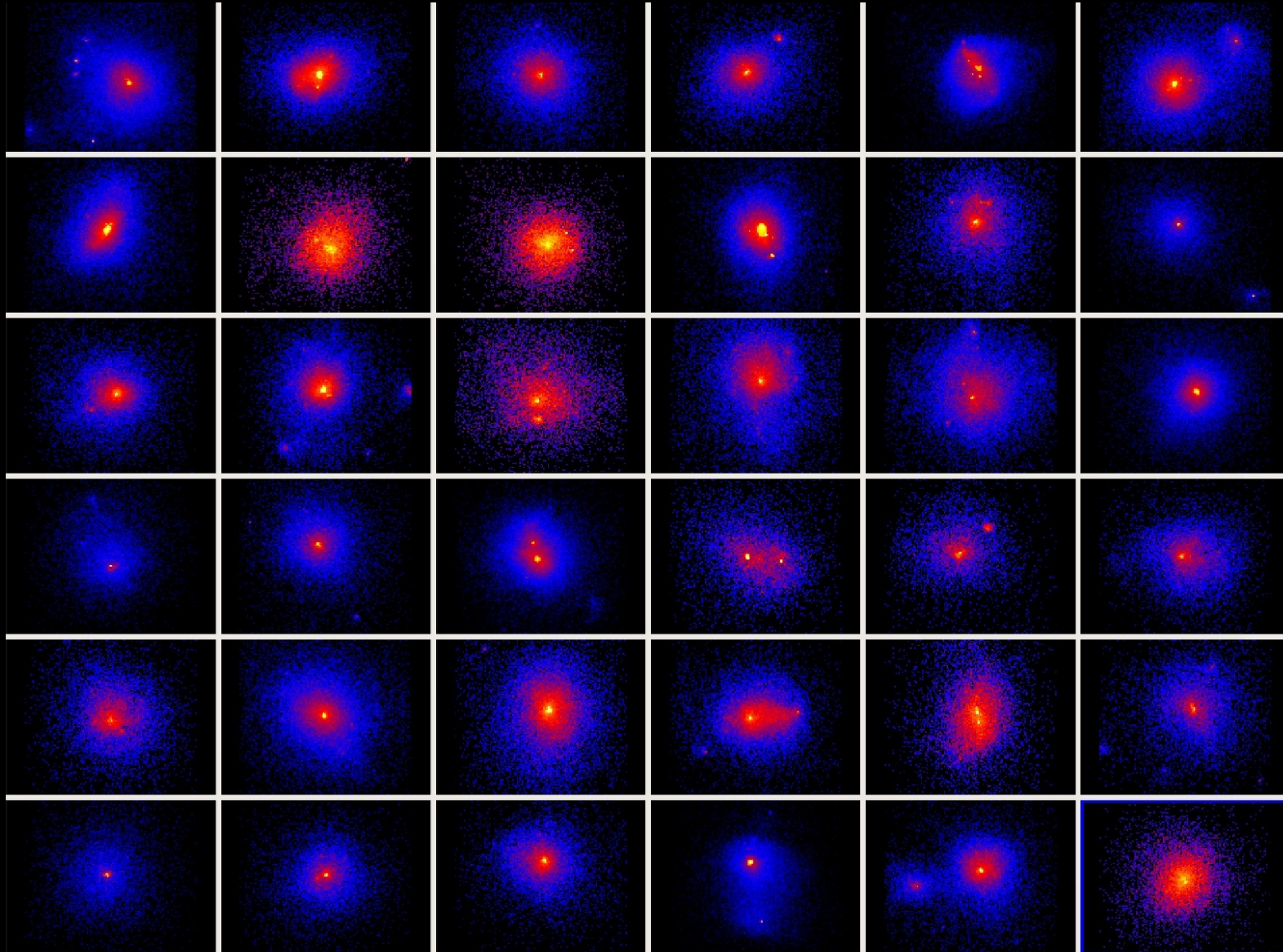
© *Rentgenski posnetki: NASA/CXC/CfA/M.Markevitch et al.;*
Optična svetloba: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.;
Zemljevid gravitacijskega lečenja: NASA/STScI; ESO WFI;
Magellan/U.Arizona/D.Clowe et al.



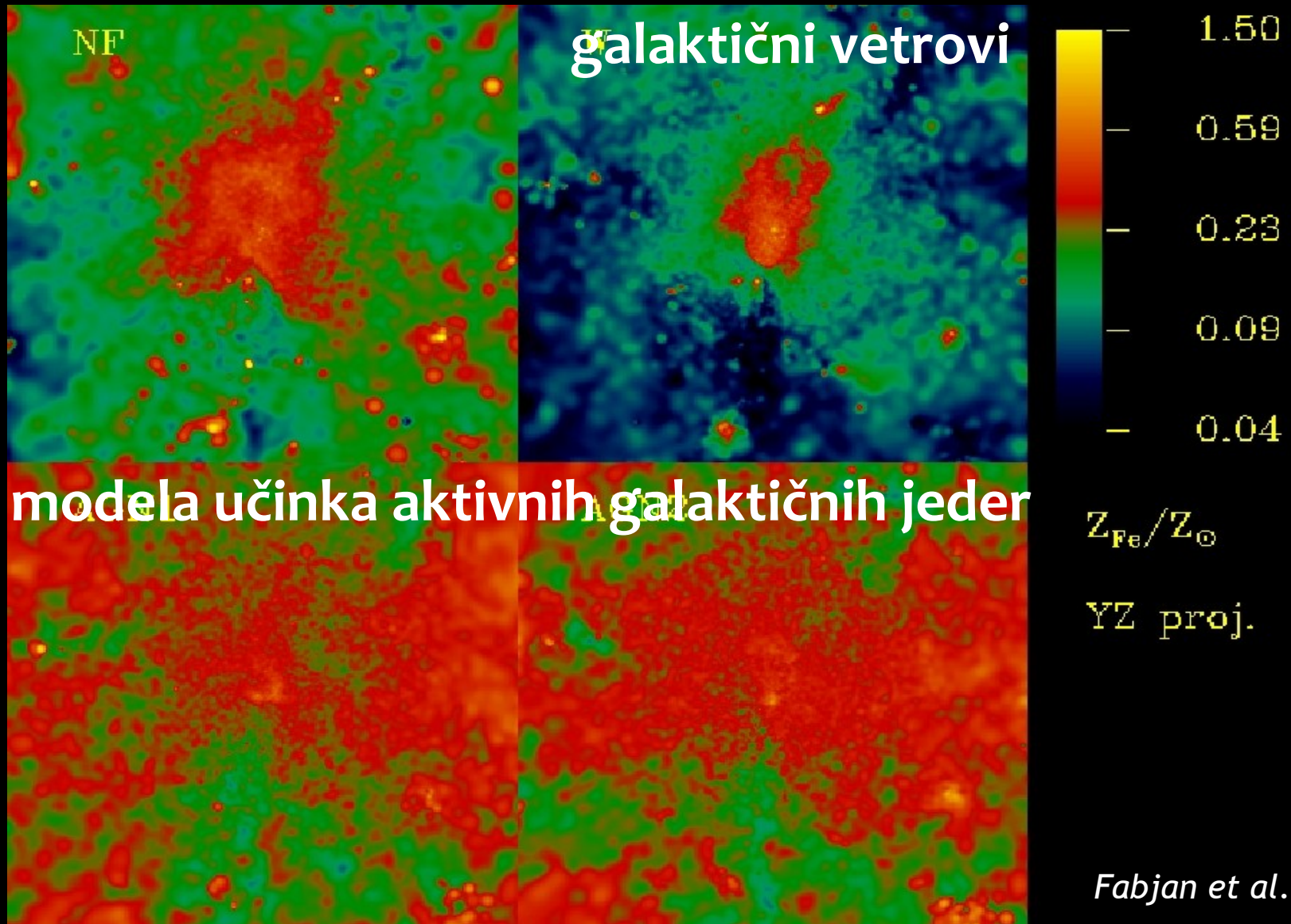


video link: http://www.mpa-garching.mpg.de/galform/data_vis/c5726_evol_mpeg4.avi

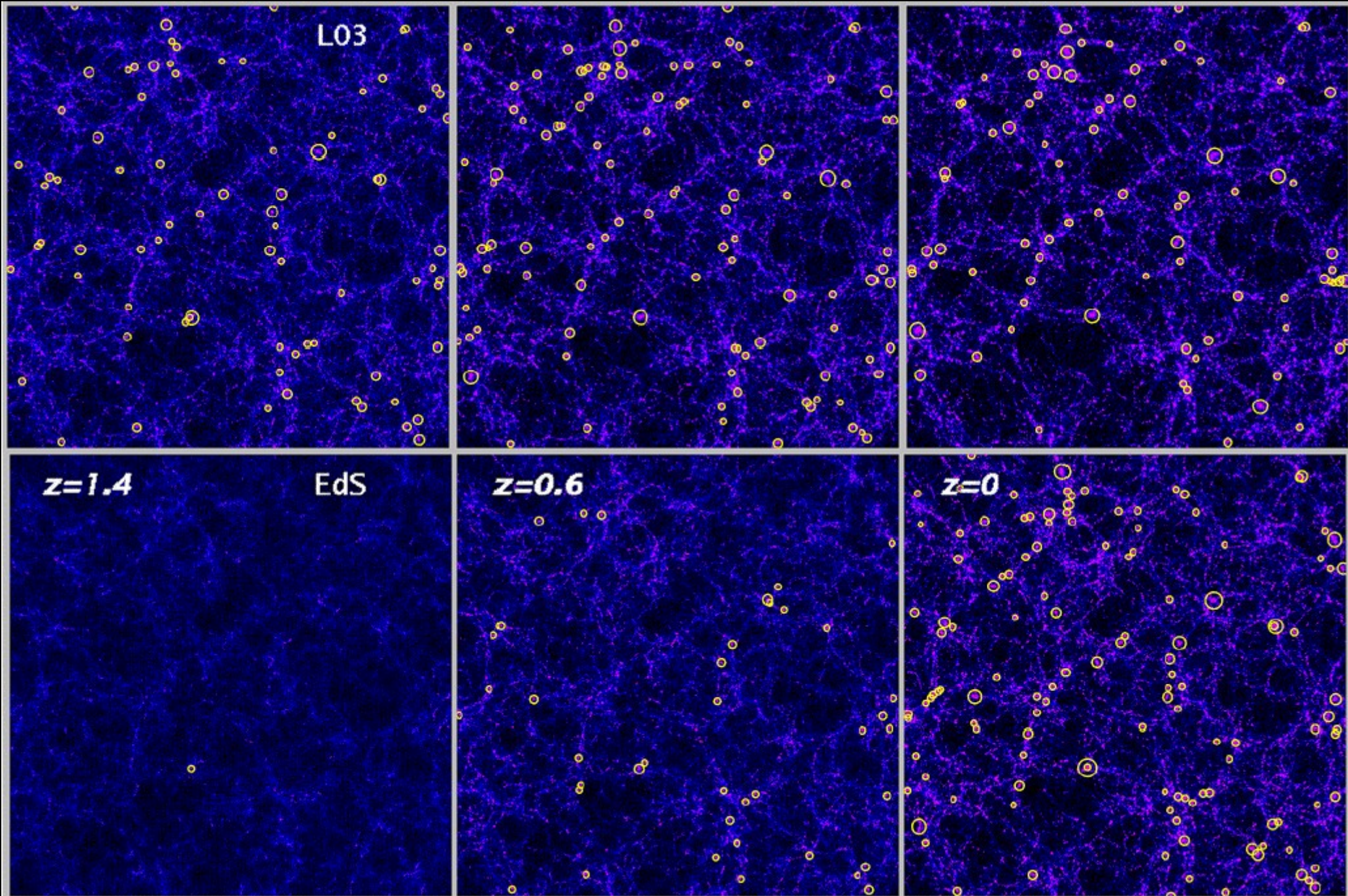
Raziskovanje s pomočjo simulacij



Zastopanost elementov v jati in različni astrofizikalni procesi



Jate in razvoj vesolja



Jate galaksij

velikani vesolja

Največji astrofizikalni laboratoriji

- visokoenergijski procesi znotraj jate lahko spremenijo njene lastnosti
- povezava med kemičnimi elementi, ki jih zvezde sintetizirajo, in njihovo zastopanostjo v plinu nam nudi informacijo o razvoju jate

Most med astrofiziko in kozmologijo

- opazovanje oddaljenih jat nam pove kako je nastajalo vesolje
- merjenje mase jat je bistvenega pomena za kozmologijo

Hvala