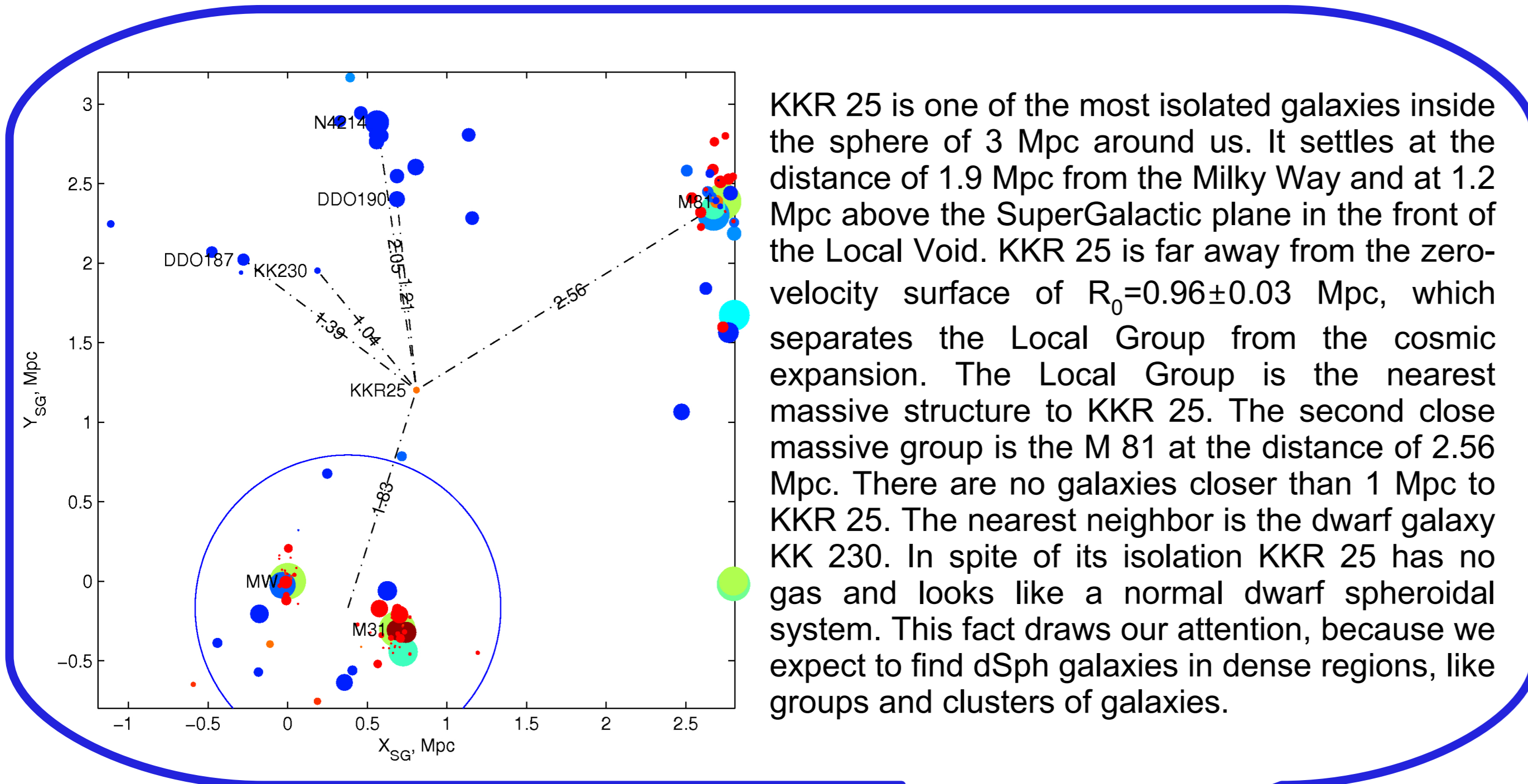


A unique isolated dwarf spheroidal galaxy at D=1.9 Mpc

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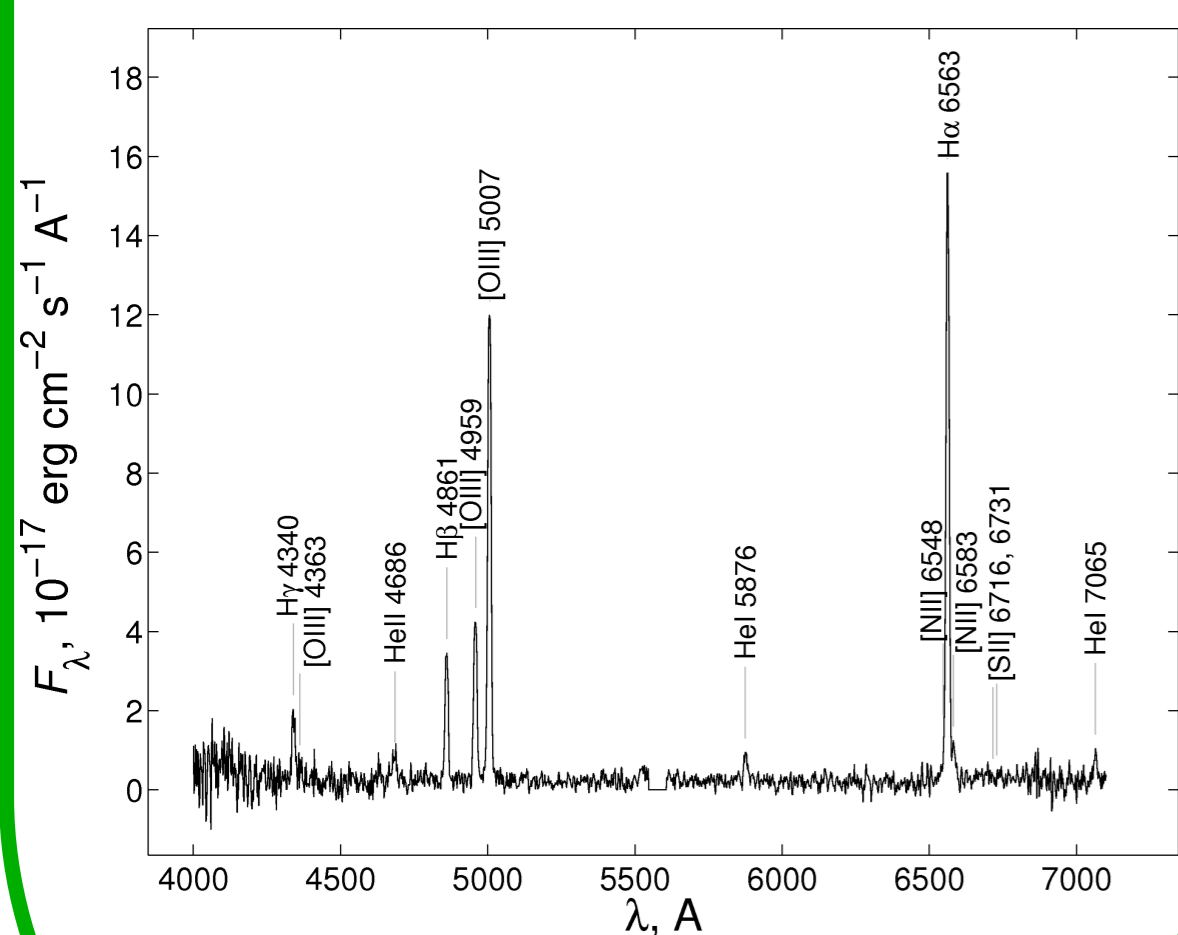


KKR 25 is one of the most isolated galaxies inside the sphere of 3 Mpc around us. It settles at the distance of 1.9 Mpc from the Milky Way and at 1.2 Mpc above the SuperGalactic plane in the front of the Local Void. KKR 25 is far away from the zero-velocity surface of $R_0=0.96\pm0.03$ Mpc, which separates the Local Group from the cosmic expansion. The Local Group is the nearest massive structure to KKR 25. The second close massive group is the M 81 at the distance of 2.56 Mpc. There are no galaxies closer than 1 Mpc to KKR 25. The nearest neighbor is the dwarf galaxy KK 230. In spite of its isolation KKR 25 has no gas and looks like a normal dwarf spheroidal system. This fact draws our attention, because we expect to find dSph galaxies in dense regions, like groups and clusters of galaxies.

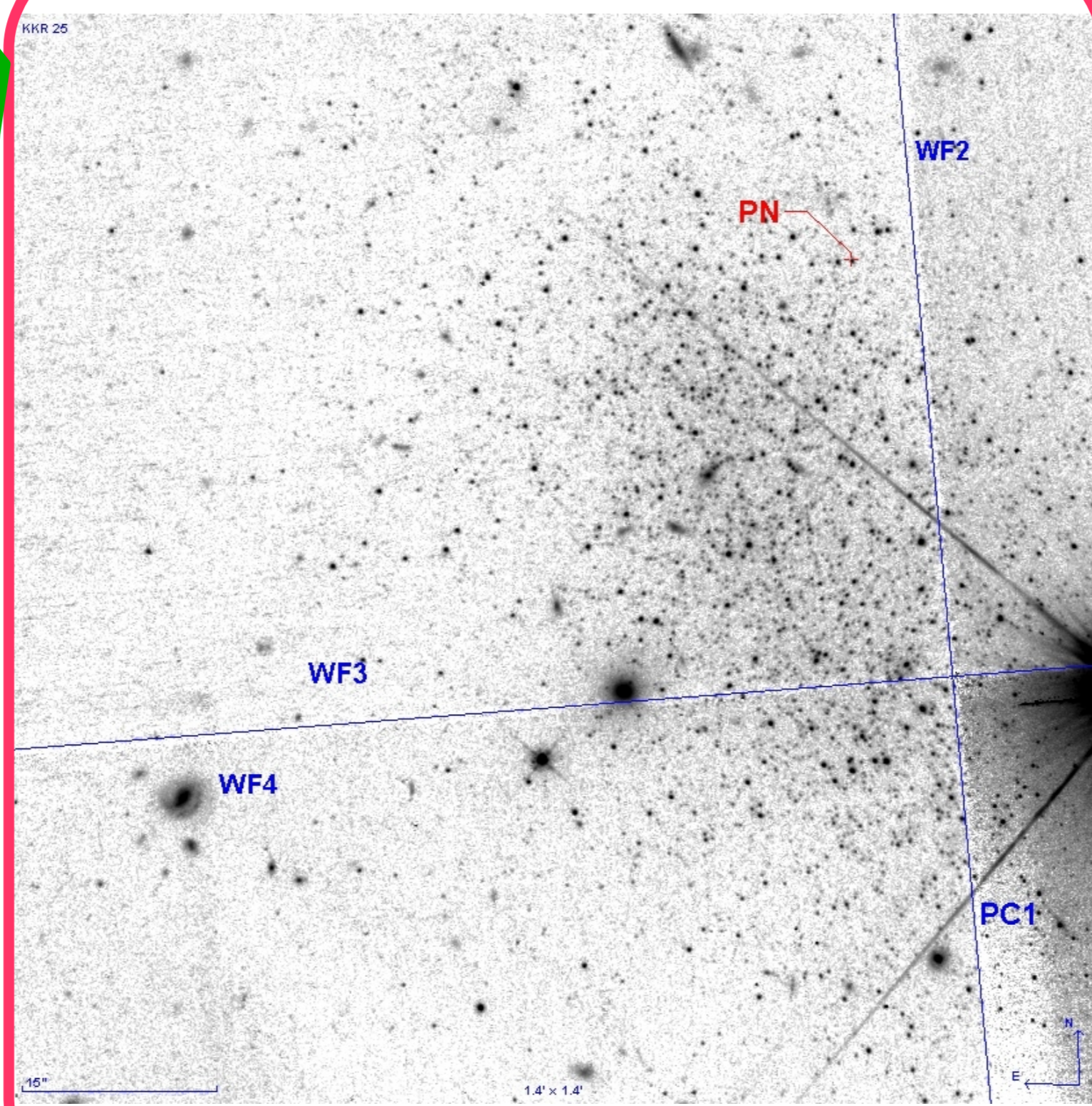
Abstract

We present a photometric and spectroscopic study of the unique isolated nearby dSph galaxy KKR25. The galaxy was resolved into stars with HST/ACS including old red giant branch and red clump. We have constructed a model of the resolved stellar populations and measured the star formation rate and metallicity as function of time. The main star formation activity period occurred about 12.6 to 14 Gyr ago. These stars are mostly metal-poor, with a mean metallicity $[Fe/H] \sim -1$ to -1.6 dex. About 60 per cent of the total stellar mass was formed during this event. There are indications of intermediate age star formation in KKR25 between 1 and 4 Gyr with no significant signs of metal enrichment for these stars. Long-slit spectroscopy was carried out using the Russian 6-m telescope of the integrated starlight and bright individual objects in the galaxy. We have discovered a planetary nebula (PN) in KKR25. This is the first known PN in a dwarf spheroidal galaxy outside the Local Group. We have measured its oxygen abundance $12+\log(O/H) = 7.60 \pm 0.07$ dex and a radial velocity $V_h = -79$ km/s. We have analyzed the stellar density distribution in the galaxy body. The galaxy has an exponential surface brightness profile with a central light depression. We discuss the evolutionary status of KKR25, which belongs to a rare class of very isolated dwarf galaxies with spheroidal morphology.

The spectroscopy of H_α object in KKR 25 revealed that it is a planetary nebula with oxygen abundance $12+\log(O/H) = 7.60 \pm 0.07$. We have serendipitously found the first PN in the dwarf spheroidal galaxy outside the Local Group. We have derived heliocentric velocity of KKR 25 using PN emission lines $V_h = -79 \pm 9$ km/s and using integrated light of the galaxy $V_h = -65 \pm 15$ km/s.



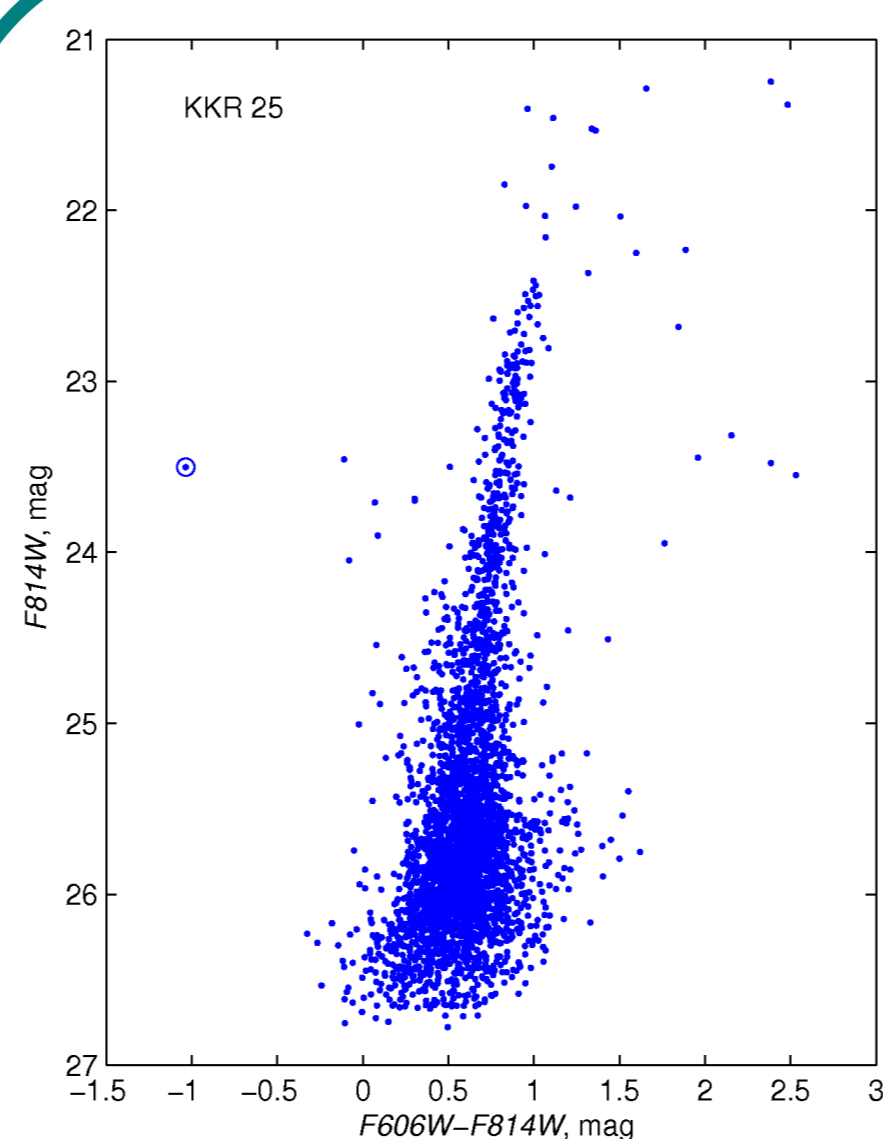
The spectrum of the H_α object.



HST WFPC2 image of KKR 25 in F814W band.

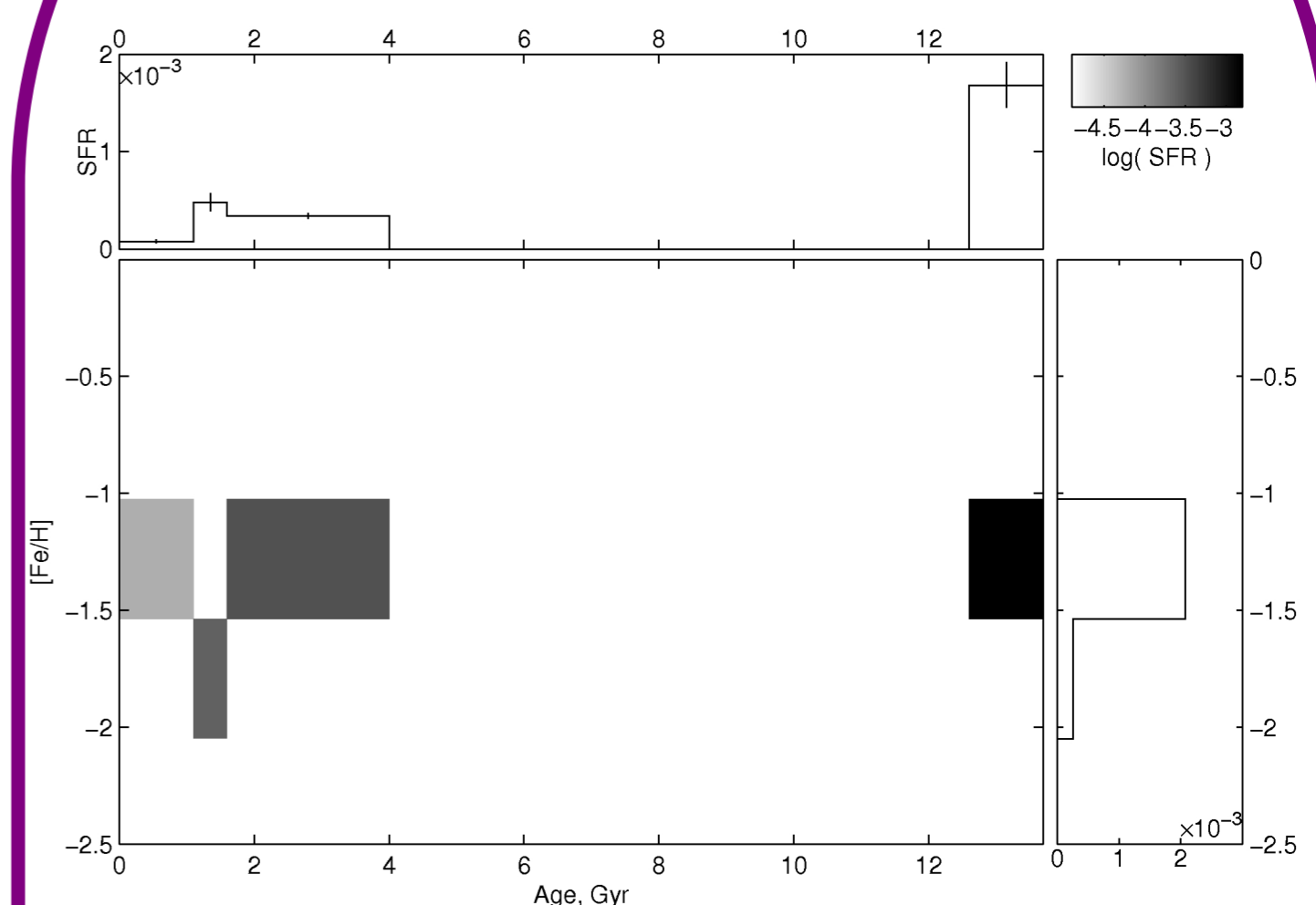
KKR 25 is one of the most isolated galaxies in the vicinity of the Local Group. It does not contain a detectable amount of gas and can be reliably classified as dwarf spheroidal galaxy. KKR 25 stays far away from any massive galaxy in the Local Volume to be affected by an interaction during its evolution. We can conclude that an evolution of KKR 25 was regulated by star formation in the galaxy itself rather than by its environment. The 'primordial scenario' proposed that dwarf spheroidals form before the reionization in small halos $M < 2 \cdot 10^8 M_\odot$.

A star formation in these halos is regulated by cooling and feedback processes in the early Universe. Simulations of pre-reionization fossils explain main properties of dwarf spheroidals in the Local Group. It seems that KKR 25 is the best candidate of such a 'fossil' galaxy.



The color - magnitude diagram of KKR 25. The planetary nebula is shown by open circle.

The star formation history of the dwarf galaxy KKR25.



According to our measurements, a main star formation event in KKR 25 has occurred 12.6 - 14 Gyr ago with a mean star formation rate (SFR) $1.7 \pm 0.2 \cdot 10^{-3} M_\odot/\text{yr}$. It is the total SFR over the whole galaxy. A metallicity range for the stars formed during this event is about $[Fe/H] = [-1.6; -1]$ dex. This initial burst accounts for 62 % of the total mass of formed stars. There are indications of intermediate age star formation in KKR 25 between 1 and 4 Gyr with no significant signs of metal enrichment for these stars. A star formation rate is lower in this period and is equal $3.6 \pm 0.5 \cdot 10^{-4} M_\odot/\text{yr}$. The measured star formation rate is very low for the recent 1 Gyr in this dwarf galaxy: $0.7 \pm 0.3 \cdot 10^{-4} M_\odot/\text{yr}$.

