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HIGH PRESSURE BEHAVIOUR OF NpTe[*]

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We have achieved high-pressure resistivity measurements on NpTe single crystal up to 21 GPa. We observe the phase transition from NaCl to CsCl phase at 13 GPa and the decrease of antiferromagnetic transition temperature $T_{\rm N}$ from 41 K to 2 K. In the NaCl phase, insulator behaviour develops: it could be described by a simple activation energy law. At the phase transition, a metallic behaviour replaces insulator behaviour with a large decrease of resistivity. Simultaneously, a sharp collapse of resistance appears at very low temperature. The origin of this collapse in the CsCl phase at T∼5 K is still unknown.

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1. Introduction

Neptunium monochalcogenides NpTe, NpSe and NpS present interesting aspects among actinides monochalcogenides with a weak antiferromagnetism and semimetal behaviour. The Uranium counterparts like UTe, USe, US are all ferromagnets, whereas PuTe, PuSe and PuS are non magnetic. UTe and PuTe undergo phase transition under pressure and their resistivity has been studied under pressure [1,2]. Susceptibility [3] and Mössbauer spectroscopy [4] on NpTe show that it becomes antiferromagnetic at $T_{\rm N} = 41$ K. But some inelastic neutrons scattering measurements did not reveal any long range magnetic order [9] although a Neel Temperature is observed. Under pressure it undergoes a phase transition around 13 GPa [5] from NaCl structure to CsCl structure with a volume collapse of 7%. It was an interesting challenge to study simultaneously the evolution of $T_{\rm N}$ and of the resistivity with pressure in the case of the phase transition.

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2. Experimental results

Single crystals of NpTe have been cleaved from X-ray characterised batches. The high-pressure device is based on Bridgman anvil cell principle. The sample and a lead foil, used as manometer, are installed in the pressure chamber define with a pyrophyllite gasket. Two disks of steatite are used as transmitting medium. The pressure is determined by the superconducting transition temperature of lead [6]. DC Resistance of sample is determined by a four-probe technique. The form factor is assumed constant with pressure. Resistivity values obtained at room temperature are close to those in the literature [3] (~ 1 mΩ.cm). The pressure diagram of resistivity of NpTe single crystal is presented in Fig. 1. At low pressure, NpTe is classically described as a Kondo compound in the NaCl structure with a $\ln T$ law from 300 K to a maximum in resistance at 50 K ($T_{\rm max}$). This is a typical aspect of competition between RKKY and Kondo interaction despite the fact that the material should be metallic [7] rather than semi metallic [7]. When increasing pressure, we observe a decrease of $T_{\rm N}$, which is no longer accessible above 8 GPa ($T_{\rm N} < 2$ K). An insulator behaviour develops above 6 GPa characterised by an activation energy law Eg from 300 K to 1.5 K. The Kondo anomaly (maximum in the resistivity) is no longer observed (Fig. 1). At the phase transition, metallic behaviour develops from 300 K to 5 K and a sharp decrease occurs below a specific temperature $T_{\rm ano}$. The resistivity is readily fit by a $T^2\exp(\frac{-\Delta}{k_{\rm B}T})$ law in this region.

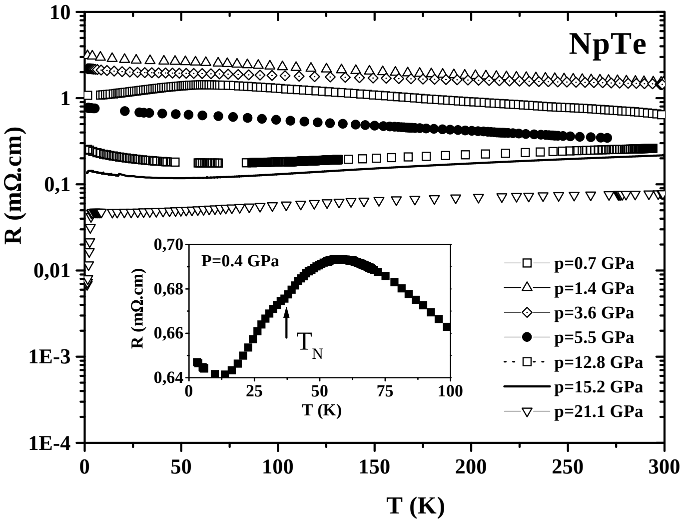

Fig. 1. Evolution of NpTe resistivity with pressure.

3. Discussion

This global behaviour with pressure (Fig. 2) is surprising. It shows similarities to pressure phase diagram of actinides monochalcogenides UTe [1] and PuTe [2]. In UTe, the ferromagnetic domain (T_C) is broadened by pressure until the phase transition after what T_C slightly decreases. In PuTe, semiconductor behaviour in NaCl phase is present. A metallic-like behaviour appears above the phase transition at 15 GPa with a collapse under 15 K of the low temperature resistance. However, PuTe has a non-magnetic ground state. In NpTe, we observe the appearance of insulator behaviour in the NaCl structure and then a metallic shape in the CsCl structure. Nevertheless, we get from the beginning a T_N signal under pressure which decreases and the magnetic state seems to disappear rapidly before the phase transition (Fig. 2). If the ordered moments are still present at this pressure, as calculated by Trinadh [8], it means that the long-range antiferromagnetic order induced by applying pressure is destroyed at that point. From U to Pu telluride compounds, we do not observe important variations of actinides atoms interspacing [5]. Therefore, the $5f$ shells overlap differences alone cannot explain the ground state properties of UTe (Ferromagnetic–RKKY interaction dominant) and PuTe (Paramagnetic–Kondo interaction dominant). Moreover, these compounds remain above Hill limit. For NpTe and PuTe cases, pressure effect reinforces insulator behaviour and we get a metallic aspect only in the CsCl structure. The low temperature behaviour observed in CsCl phase in NpTe and PuTe is very interesting. Magnetisa-

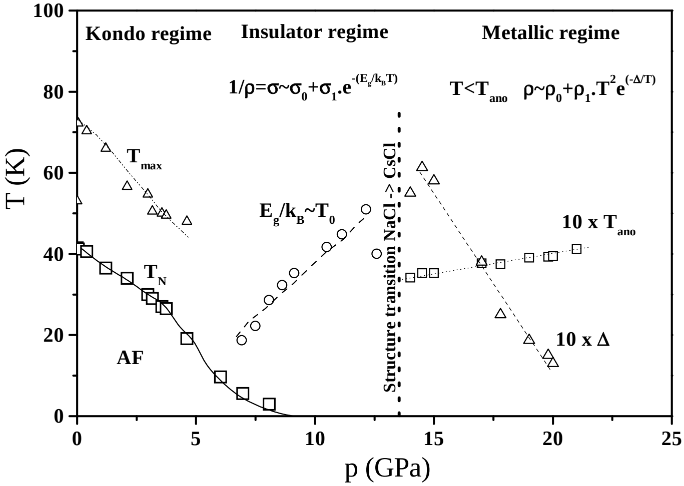

Fig. 2. NpTe pressure phase diagram.

tion, Mössbauer, or neutron diffraction at high pressure (∼ 15 GPa) and at low temperature (∼ 5 K) could give us information about the existence of a magnetic structure.

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