Fluctuation refers to the **variability** or **changes over time** in a particular measure or phenomenon. In the context of the study you mentioned on **deep brain stimulation (DBS)** and **local field potentials (LFPs)** in Parkinson's disease (PD), “fluctuation” describes the **variation** in **neural activity** (specifically LFP power) across different behavioral states (e.g., sleep and wakefulness) over time.

In the Context of the Study:

1. **LFP Fluctuations**: In this case, **LFPs** are **electrical signals** recorded from the **subthalamic nucleus (STN)** in patients with PD who are undergoing DBS. The **fluctuation of LFP power** refers to the changes in the **amplitude** or **strength** of these signals as the patient transitions between sleep and wakefulness.

2. **State-Dependent Fluctuations**: The study finds that LFPs fluctuate differently during **wakefulness** compared to **sleep**, with **LFP power** being higher during wakefulness than during sleep. This means that the strength of the electrical oscillations recorded from the STN **varies depending on whether the person is awake or asleep**. Such fluctuations can be used as markers to differentiate these two states.

3. **Diurnal Fluctuations**: The term **diurnal fluctuations** refers to the **variations** in LFP activity that occur over the **course of a day** (following the natural sleep-wake cycle). In the study, the fluctuations in LFP power were more strongly correlated during the **nighttime**, indicating that the sleep-wake cycle has a distinct effect on the **oscillatory patterns** in the STN.

Why Is Fluctuation Important in This Context?

- **Biological Significance**: The fluctuation of LFPs across the sleep-wake cycle is important because it provides insight into how the brain’s **neural activity** is linked to **behavioral states** like sleep and wakefulness. In PD, where there is already **abnormal neural oscillation**, understanding these fluctuations may help improve treatments such as DBS for both **motor** and **non-motor** symptoms, like sleep disorders.

- **Clinical Implications**: The ability to monitor LFP fluctuations could potentially lead to **closed-loop DBS systems**. These systems would adjust the stimulation parameters in real-time based on fluctuations in brain activity, offering a **personalized approach** that adapts to the patient’s **natural sleep-wake cycle** and improves the management of symptoms, such as sleep disturbances, in PD.

In summary, “fluctuation” in this study refers to the **variability** in the **power of LFP signals** across different times of day, particularly distinguishing between sleep and wakefulness. This could provide crucial data for refining **closed-loop DBS systems** and improving care for PD patients with sleep disorders.