```python
import requests
import json

# ================================
# 1. SYSTEM + USER PROMPTS
# ================================

system_prompt = """
You are an expert Research Scientist in Quantum Information Retrieval.
You write in a formal academic tone suitable for graduate-level coursework.
You strictly follow task constraints and produce structured, complete outputs.
"""

research_prompt = """
Task: LLM-Driven Research Query Expansion for Quantum Information Retrieval

Input Query:
"Quantum embeddings for multilingual indexing"

Your Output MUST include the following clearly labeled sections:

SECTION A: Expanded Research Queries
- Generate exactly 5 expanded research queries.
- Each query must explicitly reference quantum concepts such as:
  Density Matrices, Hilbert Spaces, Quantum Superposition, or Entanglement.

SECTION B: Scientific Justification
- For EACH expanded query, explain the physical or mathematical reasoning
  for why the quantum formulation improves multilingual information retrieval.
- Relate quantum formalisms to semantic alignment, uncertainty modeling,
  or cross-lingual representation.

SECTION C: Experimental Validation
- Propose exactly 3 concrete experimental setups.
- Each experiment should include:
  • Hypothesis
  • Methodology
  • Expected outcome

SECTION D: Datasets and Evaluation Metrics
- Suggest suitable multilingual datasets.
- Recommend appropriate IR evaluation metrics.

Constraints:
- Use long-context, step-by-step reasoning.
- Avoid vague claims or metaphors without explanation.
- Write in a concise but rigorous academic style.
"""

print("--- Sending request to Nous: Hermes 3 70B (OpenRouter) ---")

# ================================
# 2. OPENROUTER API CALL
# ================================

response = requests.post(
    url="https://openrouter.ai/api/v1/chat/completions",
    headers={
        "Authorization": "Bearer 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",
        "Content-Type": "application/json",
        "HTTP-Referer": "http://localhost:8000",   # Optional
        "X-Title": "QuantumIR_Research_Bot"        # Optional
    },
    data=json.dumps({
        "model": "nousresearch/hermes-3-llama-3.1-70b",
        "messages": [
            {"role": "system", "content": system_prompt},
            {"role": "user", "content": research_prompt}
        ],

        # ================================
        # 3. GENERATION PARAMETERS
        # ================================
        "temperature": 0.3,          # Lower = more academic & stable
        "top_p": 0.9,
        "max_tokens": 1800,          # Enough for long reasoning
        "frequency_penalty": 0.2,
        "presence_penalty": 0.1,
        "stream": False
    })
)

# ================================
# 4. OUTPUT HANDLING
# ================================

if response.status_code == 200:
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if response.status_code == 200:
    data = response.json()
    print("\n--- MODEL OUTPUT ---\n")
    print(data["choices"][0]["message"]["content"])
else:
    print(f"Error {response.status_code}: {response.text}")
```

```
--- Sending request to Nous: Hermes 3 70B (OpenRouter) ---

--- MODEL OUTPUT ---

SECTION A: Expanded Research Queries

1. Quantum density matrix representations for multilingual term indexing
2. Hilbert space embeddings of polysemy and synonymy in cross-lingual information retrieval
3. Quantum superposition states for modeling uncertainty in multilingual query expansion
4. Entangled vector spaces for aligning semantic meaning across languages
5. Quantum-inspired tensor networks for compositional multilingual semantic indexing

SECTION B: Scientific Justification

1. Quantum density matrices can encode the probabilistic nature of term co-occurrence across multiple languages, providing a principled way

2. Representing polysemy (multiple meanings of a term) and synonymy (different terms with the same meaning) as vectors in a high-dimension

3. The inherent uncertainty in query expansion, especially in a multilingual setting, can be elegantly captured by the superposition princ

4. Entanglement, a quintessential quantum phenomenon, can be leveraged to create vector spaces where the semantic meaning of terms is intr

5. Tensor networks, inspired by quantum computing, provide a powerful framework for composing complex multilingual semantic representation

SECTION C: Experimental Validation

1. Hypothesis: Quantum-inspired indexing techniques will outperform classical methods in terms of retrieval accuracy and efficiency.
   Methodology: Implement a quantum-inspired multilingual indexing system and compare its performance against a state-of-the-art classical
   Expected Outcome: The quantum-inspired system will demonstrate superior retrieval accuracy and efficiency due to its ability to better r

2. Hypothesis: Quantum superposition-based query expansion will improve the effectiveness of cross-lingual information retrieval.
   Methodology: Conduct a controlled experiment comparing the performance of quantum superposition-based query expansion against tradition
   Expected Outcome: The quantum approach will yield higher precision and recall by better capturing the probabilistic nature of query-term

3. Hypothesis: Entanglement-based semantic alignment will enhance the quality of cross-lingual information retrieval.
   Methodology: Develop an entanglement-based alignment algorithm and evaluate its impact on retrieval performance using a multilingual dat
   Expected Outcome: The entanglement-based approach will improve semantic consistency across languages, leading to more accurate retrieva

SECTION D: Datasets and Evaluation Metrics

Suitable multilingual datasets for evaluating quantum-inspired information retrieval techniques include:

1. Europarl parallel corpus
2. United Nations Parallel Corpus
3. OpenSubtitles parallel corpus

Recommended IR evaluation metrics:

1. Precision@k
2. Recall@k
3. Mean Average Precision (MAP)
4. Normalized Discounted Cumulative Gain (NDCG)
5. Cross-lingual Equivalent Retrieval (CLER) metric

These metrics will provide a comprehensive assessment of the effectiveness and efficiency of quantum-inspired multilingual information ret
```